TIME TO VENTURE

Scaling up Transformational Climate Tech in India

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THEIA VENTURES

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The authors' views are their own.

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Foreword

Mannat Jaspal and Priya Shah

India is currently undergoing a significant energy transition, fuelled by the urgency of addressing climate change and ensuring energy security. India's net-zero targets for 2070 and its interim climate commitments for 2030 augur a period of rapid low-carbon economic growth. While India does heavily rely on fossil fuels, it has also set up ambitious renewable energy targets, aiming to achieve 450 GW of renewable energy by 2030.[1] This push towards renewables is a fundamental part of India's strategy to reduce its carbon footprint. India's energy landscape is characterised by diversity and complexity, with the unique imperative of balancing between environmental sustainability, energy security, and economic growth.

Within this context, climate tech ecosystems are a crucial lever in India's energy transition strategy, with the aim to facilitate innovation and business models that disrupt traditional energy systems and drive the adoption of clean technologies. India is witnessing a significant growth of climate tech startups and the facilitating environment that is emerging to support them. As per an Impact Investors Council (IIC) report,[2] India has over 120 funded climate technology startups, which have collectively raised funding from over 272 different investors from across the country. Globally, India holds the 9th position in terms of venture capital (VC) funding for climate technology.[3] Furthermore, investments

in climate technology in India have seen a substantial surge, rising to an impressive US$3.7 billion in 2022 from around US$100 million in 2015. This has been facilitated by growing government support through conducive regulations and incentives, coupled with the rising commercial viability of climate-tech investments.

In a business-as-usual scenario, climate change can cost the Indian economy over US$ 33 million in the next 50 years, however, investing in climate solutions can add almost US$ 11 trillion to the economy in the same time frame, according to a study by Deloitte.[4] These solutions have the potential to foster innovation, promote market competition, encourage job creation, and create employment opportunities while addressing serious social challenges. This becomes particularly salient in a developing economy context, helping to advance a people positive energy transition. It is becoming increasingly clear that investing in climate tech solutions is crucial for both environmental sustainability as well as socio-economic development. A report by Unitus Capital and Climake suggests that India is projected to invest around US$ 1.01 trillion in climate action initiatives from 2022 to 2030, with an average annual investment of approximately US $112 billion.[5]

Despite these promising developments, the climate tech ecosystem in India is at an incipient stage and leaves much to be desired. The lack of substantial risk capital continues to remain the most persistent challenge. Furthermore, there continues to be a sectoral bias towards renewables and electric vehicles for instance,[6] with other emerging sectors struggling to attract substantial investments. To illustrate, investments of around US$ 300 billion are needed for sustainable food value chains by 2030, while approximately US$ 200 billion is required for water and solid waste management, and about US$ 60 billion for demand-side energy management, according to the State of Climate Finance in India report.[7] The private equity and venture capital community must recognise the vast potential in investing in these emerging sectors and across different stages.

This compendium is an effort to showcase some success stories from India's diverse climate tech ecosystem, providing inspiration and valuable insights to encourage the proliferation of climate tech start-ups and stimulate increased VC and Private Equity (PE) investments in this sector.

It brings together perspectives from both startup founders and venture capital funds in India, operating and investing in climate technologies.

The first set of essays profiles 11 early-stage companies that are part of a fast-evolving climate tech ecosystem in India, which are innovating on business models across multiple sectors. These range from energy efficiency, climate risk analytics, carbon markets, water tech, green hydrogen, electric mobility, grid infrastructure, solar panel hardware, and microbial fermentation for methane gas conversion. Each company highlights the current market landscape, where decades of excessive reliance on fossil fuel-enabled products and manufacturing practices have led to rising temperatures and carbon emissions. This has created urgency to find long-term, sustainable alternatives to combat climate change, in particular, deep science-based technology tools, which can have the potential to disrupt the petrochemical and hydrocarbon-fuelled status quo.

These start-ups showcase, through the description of their technology solutions, the widespread social impact of their models on communities that are most vulnerable to the effects of rising carbon emissions. Moreover, they discuss the challenges faced when building and deploying these solutions in the Indian market, including the low availability of a diverse capital base to underwrite the risk of these technologies, as well as customer awareness and adoption, particularly among industrial houses. The essays in this compendium also underscore the role of various stakeholders, such as governments, think tanks, industry organisations and academia, to address these challenges. Suggested solutions include: i) unlocking the flow of public and private capital to support early-stage ventures; ii) improving awareness of greener substitutes for commercial and industrial customers; and iii) providing inputs into policy recommendations to achieve a successful transition to a low-carbon economy.

Furthermore, in the second set of essays, six venture capital funds discuss a wide range of emerging opportunities in the climate tech venture ecosystem in India, which have the potential to both i) create outsized financial returns; and ii) catalyse these companies to build solutions that mitigate or adapt to the effects of climate change. These funds dive into the formulation of their investment strategy, which typically cuts across

various sectors to constitute a climate tech mandate, as well as their preferences for deep tech ventures with large capex overlays, compared with asset-light models akin to traditional software investing. Additionally, these funds engage with the challenges associated with deploying capital into this space, citing the need for effective collaboration between other capital providers such as banks, philanthropic (risk-free) capital, industrial players, university R&D labs, and the government.

This publication therefore aims to bring to the forefront the wide range of opportunities for practitioners and capital providers alike to drive private sector involvement in climate action solutions. India is uniquely placed to be at the forefront of the net zero climate transition, due to a confluence of positive factors encouraging the growth of early-stage venture activity. These include a highly skilled pool of talent, both in scientific research and in investing expertise, as well as a large landmass of natural resources. Furthermore, supportive government regulations such as the notable Electricity Amendment Act, the Green Hydrogen Policy, and the National Policy on Biofuels represent critical steps towards advancing the green growth agenda. Furthermore, the narrative of "Make in India for the World" presents an immense opportunity for India to become a hub of climate tech solutions. Nevertheless, India still has a long way to go to create a truly organic enabling environment for deep tech climate startups to operate, particularly when it comes to optimising the role of academic institutions to foster cutting-edge research; encouraging industry actors to support prototype development through engaging with start-ups; and developing differentiated capital asset classes to allocate funding to climate tech venture growth.

Given the state of the climate emergency, it is crucial to create an actionable blueprint to tackle these challenges through innovative climate tech solutions and investments so India can stay on course to meet its set climate targets. This will in turn help early-stage companies galvanise the tools they need to achieve scale and thereby widespread adoption of their solutions. It is therefore ORF and Theia Ventures' aim that this collection of essays helps frame current discussions on lending active support to this vibrant and burgeoning climate tech ecosystem in India. We hope you enjoy the read!

Endnotes

1 India needs a doubling of installs to deliver on PM Modi's 450 GW by 2030 ambition, *Energyworld,* December 15, 2022, https://energy.economictimes.indiatimes.com/news/renewable/india-needs-a-doubling-of-installs-to-deliver-on-pm-modis-450-gw-by-2030-ambition/96246672

2 Deepanshi Balooni, Ramraj Pai, and Shriya Nene, "Climate tech start-ups: The need of the hour", *idr*, November 4, 2021, https://idronline.org/article/climate-emergency/climate-tech-start-ups-the-need-of-the-hour/

3 India and Climate Tech: Unleashing India's Green Investment Potential, Climateangels, https://climateangels.in/insights/india-climate-tech/#:~:text=According%20to%20a%20report%20by,VC%20funding%20for%20climate%20tech.

4 Deloitte, https://www2.deloitte.com/in/en/pages/about-deloitte/articles/turning-point-press-release.html

5 Venkat Neelakantan, "Understanding climate tech, its value and promise", *The Times of India,* 22 April, 2023, https://timesofindia.indiatimes.com/blogs/voices/understanding-climate-tech-its-value-and-promise/

6 Priya Shah, Promit Mookherjee, and Urvi Tembey, *Financing Climate Tech in India: Insights from a Dialogue with Entrepreneurs and Investors,* June 2023, Observer Research Foundation

7 Priya Shah, Promit Mookherjee, and Urvi Tembey, *Financing Climate Tech in India: Insights from a Dialogue with Entrepreneurs and Investors*

I

Building Last-Mile Electrification for Sustainable Mobility

Arun Vinayak, Sanjay Byalal, and Siddharth Sikchi

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I. The rise of electric vehicles in the logistics sector

India has grown from the 12th largest economy in the world in 2003 to the 5th largest economy in 2023.[1] Economic growth in the last two decades has increased the demand for energy in transport, industry and agriculture, which has led to a 142 percent rise in the level of carbon emissions.[2] In addition, rapid urbanisation has led to an increase in the per capita consumption of goods and services. This has, in turn, led to an increase in per capita emissions by 93 percent between 2003 and 2022, from production and transportation of these goods and services.[3]

The rise of the Indian e-commerce industry has particularly fuelled India's economic growth and the subsequent increase in emissions.[4] India shipped over 4 billion packages in FY23, including in-house logistics and third-party players. The market is expected to witness a 10x hike to the delivery of 40 billion parcels per year by 2030 and carbon emissions could be as high as 8 million tonnes. Research also suggests that India's last mile emissions per delivery (285 gCO_2) are significantly higher than the global weighted average (204 gCO_2) and that the five Indian metro cities—Delhi, Mumbai, Kolkata, Bangalore, and Chennai—emit more CO_2 emissions in their last-mile deliveries than the logistics sectors of countries such as France and Canada.[5]

We believe that India needs to prioritise transport solutions that are both clean and affordable. One solution is switching to electric vehicle fleets for last-mile delivery. This is expected to reduce emissions by 1.5 million tonnes every year by 2025, if these vehicles are electrified.[6] This is equivalent to reducing 300,000 cars on the road. Moreover, it is estimated that we could see a 14 percent reduction in carbon emissions by 2030 if the small commercial vehicle segment, characterised by three-wheelers (3W), were fully electrified.[7] India has seen a push in this direction in the form of government policies such as the National Electric Mobility Mission Plan (launched in 2013) and the FAME II scheme (launched in 2019).[8]

The push for electrification has also led to economic growth and innovation across different fronts, such as innovations in battery technology, charging infrastructure, and digital logistics platforms. Nevertheless, the adoption of Electric Vehicles (EVs) in the 3W segment has been slow due to high upfront costs, lack of reliable charging infrastructure, and low consumer awareness. Affordable last-mile logistics is directly proportional to the utilisation of the vehicle. In other words, the higher the distance travelled by an EV, the lower the ownership and operational costs. The same logic of utilisation applies to setting up a successful EV charging network. If a charging station can sell energy to more EVs in a given day, through economies of scale, the cost of charging an EV becomes more affordable. Due to under-utilisation, EVs have not been able to demonstrate their true value, which has also impacted the scale at which charging networks can be successfully established and made profitable.

One of the main reasons for the under-utilisation of electric 3Ws in logistics is the extended time to charge. Last-mile logistics operators cover an average of 150 km in a day, while EVs fitted with large battery packs are only able to realistically deliver a range of 100 km on a single charge. With longer charging times, logistics players are forced to deploy 2 vehicles to cover the required distance—thereby increasing their cost of operations. Additionally, there are parking charges that EV fleet operators or owners incur to charge their vehicle, for periods of three to five hours.

To combat charging anxiety, vehicle manufacturers often install EVs with larger battery packs. This increases the price of the vehicle, rendering it an unviable option for service providers and fleet operators. Another challenge that last-mile logistics providers face with respect to EV adoption is the length of battery life. Currently, commercial 3W EV batteries provide 1,500 charges and result in 30 percent battery degradation. Battery degradation is an outcome of charging, and batteries and chargers built by two separate manufacturers often fail to effectively work together. For the first time in the automotive industry, the energy that powers a vehicle has a direct impact on the life and

performance of the vehicle itself. Hence, it is important for EV charging providers to work in synergy with battery and EV manufacturers.

II. Exponent energy's rapid charging solution for commercial EVs

At Exponent Energy, we have developed a solution that solves the problems of:

(1) Long charging time;
(2) Short battery life; and
(3) High cost of operations for commercial vehicles.

Exponent is a full-stack energy company that builds battery packs (e^pack) and charging stations (e^pump) that work together to unlock a 0 percent to 100 percent charge in 15 minutes, and provides a 3,000 cycle life warranty while using regular Lithium-ion cells.

We partner with vehicle manufacturers to i) integrate the e^pack into their existing vehicles; ii) create a 15-minute rapid charging variant; and iii) simultaneously establish a charging network with e^pumps across various cities. As of today, we have partnered with Altigreen Propulsion Labs to create the world's fastest-charging 3W called the neEV Tez.[9] The neEV Tez features an 8.2kWh battery pack, which is 30 percent smaller than the regular neEV variant. A smaller battery pack with a 3,000-cycle life warranty and five year financing ensures that the EV is 30 percent more affordable.[10]

Through partnerships with last-mile logistics companies such as Magenta Mobility, FYN Mobility and others, Exponent has deployed over 300 EVs with its proprietary e^pack and covered over 2 Million kms on the road to date. We have completed over 40,000 rapid charging sessions on a network of 30 e^pumps spread across the city of Bengaluru. Among the 30 e^pumps set up, at least 10 e^pumps charge an average of 25 EVs per day. While we are currently operating in Bengaluru, we plan to enter five new cities in India by the end of FY23.

III. Key challenge

Energy has fundamentally transformed in the automobile world. In petrol vehicles, otherwise known as Internal Combustion Engines (ICE), energy companies were decoupled from vehicle manufacturers, as they had minimal impact on the life and performance of the vehicles they powered. In this way, the process of transferring energy was simple and mechanical.

What changed with EVs was the advent of battery packs (with complex chemicals) on one end and charging stations (transmitting high quantities of electricity) on the other. How a charger powers a battery fundamentally impacts the life and performance of the vehicle itself (as the battery is ~50 percent of the cost of an EV). Therefore, the process of transferring energy in EVs is a complex two-sided problem.

Solving this required us to build a company with a fundamentally unique DNA. We needed to not only maintain advanced R&D and engineering capabilities, but also develop a distinct business and operational acumen

to provide a seamless charging experience for customers as frequently as twice a day. Achieving this balance has been the most challenging experience for us.

IV. Recommendations for key stakeholders

So far the government has excelled in encouraging companies to foray into the EV space with the Production Linked Incentive Scheme (PLI) scheme,[11] as well as the FAME scheme[12]—both of which incentivise consumers to purchase EVs. Moreover, the new AIS-156 standards urge EV manufacturers to follow best practices in vehicle development, leading to higher-quality EVs on the road.[13]

Moving forward, to catalyse the electrification journey, a policy move that can benefit the ecosystem is to implement performance-linked incentives for charging infrastructure players, purely on the basis of the energy throughput that their network achieves. This will ensure charging networks that are able to sell energy consistently will be financially incentivised, leading to the growth of a high-performing and robust charging infrastructure.

V. Way forward

As we scale our solution to more cities, we plan to continue to partner with multiple vehicle manufacturers to integrate our e^pack and create several 15-minute rapid charging variants. We also plan to ensure that we have a dense e^pump network in every city we enter (one e^pump at every 2km radius). Considering the promising future of sustainable mobility in India, and in keeping with the increasing demand for EVs in the logistics sector, our aspiration is to deploy sufficient Exponent-powered EVs to build towards an efficient, widely utilised and profitable charging network.

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Endnotes

1 Rumki Majumdar, "India Economic Outlook, October 2023," *Deloitte Insights*, https://www2.deloitte.com/us/en/insights/economy/asia-pacific/india-economic-outlook.html#

2 "Greenhouse gas emissions rise at fastest rate for 30 years," *The Guardian*, 9 September, 2014, https://www.theguardian.com/environment/2014/sep/09/carbon-dioxide-emissions-greenhouse-gases

3 Jyothi Thakur, "Explained: What Is Carbon Footprint? How Countries Calculate And Regulate It?," *India Times*, October 27, 2021, https://www.indiatimes.com/explainers/news/what-is-carbon-footprint-552600.html

4 Mrityunjay Bose, "Indian e-commerce and emissions to grow exponentially: Report", *Deccan Herald*, May 24, 2023, https://www.deccanherald.com/business/indian-e-commerce-and-emissions-to-grow-exponentially-report-1221537.html

5 Mrityunjay Bose, "Last mile emissions per delivery higher in India than global average," *Deccan Herald*, July 14, 2022, https://www.deccanherald.com/india/last-mile-emissions-per-delivery-higher-in-india-than-global-average-1126454.html

6 Vikram Janakiraman, Natarajan Sankar, Aditya Khandelia and Aditi Tiwari, "*Electric Vehicles: Future of Last Mile Deliveries in India*," Boston Consulting Group, 2023, *https://www.bcg.com/publications/2023/electric-vehicles-future-of-last-mile-deliveries-in-india*

7 Sharif Qamar, "Roadmap for Electrification of Urban Freight in India," *The Energy Resources Institute*, August 1, 2019, https://www.teriin.org/project/roadmap-electrification-urban-freight-india

8 Rohan Rao, Parveen Kumar and Pawan Mulukutla, "Accelerating Electrification of Small Commercial Freights in India", *WRI India*, January 14, 2022, https://wri-india.org/blog/accelerating-electrification-small-commercial-freights-india

9 Issha Rautela, "Automobile. Altigreen launces fast-charging cargo EV at ₹3.55 lakh," *Businessline*, January 9, 2023, https://www.thehindubusinessline.com/companies/altigreen-launches-fast-charging-cargo-ev-at-355-lakh/article66357100.ece

10 "Exponent and Alt Mobility announce 5-Year EV financing with 30% lower EMI," *Autocar professional*, May 31, 2023, https://www.autocarpro.in/news/exponent-and-alt-mobility-announce-5-year-ev-financing-with-30-lower-emi-115272

11 "PLI schemes push e-mobility adoption, 2.57 lakh electric vehicles registered in India till March 15: Minister," *ETGovernment*, March 22, 2023, https://government.economictimes.indiatimes.com/news/smart-infra/pli-schemes-push-e-mobility-adoption-2-57-lakh-electric-vehicles-registered-in-india-till-march-15-minister/98890549#:~:text=Production%20linked%-20incentive%20(PLI)%20scheme,covered%20under%20this%20PLI%20scheme

12 Ministry of Heavy Industries, Government of India, https://pib.gov.in/Pressreleaseshare.aspx?PRID=1566758

13 Venkat Rajaraman, "AIS 156 Standard- additional safety requirements | Practitioner's Perspective," *EVreporter*, September 9, 2022, https://evreporter.com/ais-156-standard-additional-safety-requirements-practitioners-perspective/#:~:text=Cell%20to%20cell%20spacing%20should,be%20maintained%20by%20the%20manufacturer

Green Hydrogen's Big Promise

Prasanta Sarkar and Anindita Mukherjee

I. Industry overview

India's endeavour to lead the global energy transition would require sustainable technological solutions to take centre stage in today's industrial and transportation landscape. Newtrace, an innovative climate-tech startup, with a purpose-driven vision to revolutionise green hydrogen (GH_2) production at scale is swiftly making its way to the forefront of this transition. Newtrace's proprietary electrolyser technology aims to address the pressing challenges of cost, supply chain, scalability, and efficiency, with the overarching goal of realising a truly sustainable, greener future for the planet.

Hydrogen (H_2) is a major source of fuel and a key raw material in hard-to-abate large-scale industries. Traditional methods of hydrogen production are highly CO_2 intensive. For example, production through methods such as steam-methane reforming (at U$2-3 / kg) emits over 900 million tonnes (Mt) of CO_2 for every 94 Mt of H_2 currently produced (aptly named 'grey hydrogen').[1] Cleaner methods of hydrogen production—although more sustainable—are highly priced (at US$6-7/kg) due to the use of critical and hard-to-procure materials in the electrolyser technology. The hydrogen thus produced is termed 'green hydrogen'.

As a result, while hydrogen is undoubtedly a cleaner fuel, current production methods are either carbon-heavy or present several bottlenecks (for example, cost, supply chain, etc.) to achieve wide-scale adoption. To counter these challenges, Newtrace is solving for an improved production method of hydrogen that is low in carbon emissions, affordable, and massively scalable. This led to the idea of Newtrace's next-gen electrolysers that use renewable electricity and water as inputs, and utilise no rare earth metals in their composition. The resulting green hydrogen is sustainable and cost-effective.

The importance of cleansing the hydrogen production value chain is gaining prominence due to increased industrial, political and social awareness, largely due to the exacerbated impacts of climate change. The shift is further bolstered by supportive government regulations, long-term investments in renewable energy, the emergence of the circular economy,

and sustainable infrastructure, along with technological advancements that have made clean energy innovations more accessible and affordable. For instance, the National Green Hydrogen Mission brought into effect in January 2023, is a remarkable initiative by the Government of India to position the country as a frontrunner in the production, adoption and export of green hydrogen over the next decade.[2]

Embracing sustainable hydrogen production and utilisation will be crucial for both economic prosperity and fostering a cleaner and more sustainable future. Newtrace, with its cutting-edge electrolyser technology, aims to contribute significantly to this fight against climate change while simultaneously bolstering India's energy security aspirations.

II. Newtrace's game-changer tech

Electrolysers are devices that use electricity to split water into hydrogen (H_2) and oxygen (O_2), after which hydrogen gas is collected and used for a multitude of industrial applications. What sets Newtrace's electrolysers apart is its patented, cutting-edge technology that delivers up to 60 percent reduction in overall production costs, while its modular design ensures scalability. The design seamlessly integrates pioneering precision fluid engineering technology to split water into H_2 and O_2, aided by an enhanced electrocatalyst that eliminates the need for rare earth metals. The technology is not only cost-effective but also promotes sustainable manufacturing operations owing to zero dependency on a long, complex supply chain. Lastly, the employment of modern automated manufacturing has drastically reduced the prototype development and testing cycles, thereby shortening lengthy turnaround times and complexities in new product development. For example, a vast spectrum of critical and complex designs is rendered by leveraging 3D printing at scale.

Growth in R&D remains one of our top focuses as we move into commercialised production. Rapid progress is being made in establishing state-of-the-art labs, keeping future expansions in mind. Our facility is equipped to handle upcoming developments in the hydrogen market

as well as the associated demand it is expected to generate. Our R&D activities have resulted in the development of a highly efficient electrocatalyst, alongside ongoing iterations of the modular stack. The team is also working on the scaling up of the Balance of Plants (BoP) for large-scale hydrogen production. We are growing our current team of 30 to ~50 by the end of 2023. Our focus is on building a strong product team across domains in electrochemistry, stack engineering, software development, and manufacturing. We are also enhancing our operational and deployment capabilities as well as building a strong business development team for the global market.

India's energy transition is squarely resting on the shoulders of the emerging indigenous technology development landscape. The country's ambitious goal to produce 5 Mt of GH_2 per annum by 2030 demands scalable and efficient technologies and infrastructure.[3] Newtrace's cost-effective, scalable electrolyser solution could boost India's capabilities in undertaking large-scale GH_2 projects that eliminate carbon emissions at an industrial scale—a step of utmost significance in abating climate change to achieve our net-zero target.

While the hydrogen ecosystem presents a plethora of opportunities to diversify our operations in the future, Newtrace is currently dedicated to offering technology for green hydrogen production in an affordable and scalable manner. Eventually, we look forward to coming together with key players in hydrogen storage, transport, and distribution, allowing for a wide spectrum of opportunities for collaborative expansion of the hydrogen ecosystem.

III. Challenges to scale and recommendations for key stakeholders

While Newtrace's vision is promising, the path to widespread adoption faces some key challenges. The primary hurdle lies in bridging the funding gap in technology development, manufacturing and large-scale green hydrogen projects. Large-scale project deployments would invariably involve conducting small-scale pilots, in addition to addressing the integration needs with end users of GH_2.

Policymakers and investors must collaborate to create conducive policy frameworks and financial incentives, encouraging startups like us to build, iterate and improve our products during their initial stages. Specialised financing such as Production Linked Incentive (PLI) schemes for green hydrogen production and electrolysers are a vital step towards initiating momentum but often neglect opportunities to support novel indigenous technology development and adoption in this sector.

Furthermore, India's industrial sectors also need to step up and embrace emerging technologies and startups. The norms of engagement must evolve to support emerging startups and their technologies, which organisations such as the Indian Space Research Organisation have done commendably for the space-tech sector. Simplified and efficient banking procedures, particularly for startups with proven potential, will expedite project execution and help startups avoid penalties due to prolonged production timelines.

To overcome supply chain challenges for indigenous technology development, a robust network of manufacturers and vendors should be developed. Newtrace's approach of conducting in-house designing and research while collaborating with vendors for manufacturing and capability enhancement could serve as a robust model for other startups. Moreover, the development of the vendor ecosystem is a time-intensive, yet very critical step towards Atmanirbhar Bharat. Additionally, a feedback-driven approach that involves industry stakeholders in technology customisation would result in more adaptable solutions that align with diverse hydrogen usage requirements.

IV. Conclusion

Newtrace's journey in the green hydrogen space exemplifies the spirit of innovation and determination that India's energy transition demands. Amidst rapid technological advancements and financial considerations, Newtrace's technology has the potential to play a transformative role in shaping India's clean energy landscape. In providing clean and sustainable energy solutions, the company aims to improve lives, empower communities, and foster environmental stewardship. Alongside continued support from policymakers, investors and industry stakeholders, Newtrace and our startup contemporaries can forge a path towards a greener, cleaner, and brighter future for India and the world.

newtrace

Endnotes

1 International Energy Agency, *Global Hydrogen Review 2022,* Paris, IEA, 2022, https://www.iea.org/reports/global-hydrogen-review-2022.

2 Ministry of New and Renewable Energy, Government of India, https://pib.gov.in/PressReleasePage.aspx?PRID=1907705#:~:text=Singh%20in%20the%20Lok%20Sabha%20Today.&text=by%20PIB%20Delhi-,On%204th%20January%202023%2C%20the%20Union%20Cabinet%20approved%20the,Green%20Hydrogen%20and%20its%20derivatives

3 Kiran K Malla, "How can India become the industrial hub for electrolyzer production by 2030," *Ernst and Young,* https://www.ey.com/en_in/energy-resources/how-can-india-become-the-industrial-hub-for-electrolyzer-production-by-2030

Enabling Climate Finance as a Tool for Inclusive Economic Growth

Rahool Gadkari, Rushil Noronha, and Arshiya Bhutani

I. The economic opportunity behind the climate transition

India's requirement for climate finance is large and growing. It is estimated that to achieve India's Nationally Determined Contributions (NDCs) under the Paris Agreement, the country requires approximately US$2.5 trillion from 2015 to 2030 or roughly US$170 billion per year.[1] The country's estimated green financing requirement will be at least 2.5 percent of GDP annually until 2030.[2]

Public sector funds are not enough to meet this massive financing requirement, therefore, India must accelerate its efforts to empower the private sector. Major corporations and financial institutions now perceive the climate transition not solely as a matter of morality and ethics, but also as a unique economic opportunity—in 2022, nearly 450 banks, insurers, and investors, collectively representing US$130 trillion in assets and 40 percent of the world's private capital, committed to making their portfolios climate neutral by 2050.[3] While ambitious commitments have been made in terms of financing climate action, accessing this pool of capital remains a challenge.

II. Neufin's solution

Neufin was founded in December 2021 with the aim of bridging this gap and ensuring that capital was not a constraint in the greening of the economy. We are building a technology platform for businesses to simplify and streamline access to green financing. Our mission is to become the platform that powers the world's transition to zero emissions. We aim to address the US$ 10 trillion/year gap in climate finance globally through innovative delivery of financial products across key stressed geographies—India, South East Asia, the Middle East, and Africa.[4]

To solve this problem, we are taking a step-wise approach starting with dismantling the complexities that exist in the carbon markets. The role that carbon markets can play in a country's decarbonisation journey is becoming increasingly evident as businesses, organisations,

and governments grapple with striking a balance between emissions reduction and economic growth. Carbon markets provide a mechanism to incentivise and fund emission reduction projects and offer cost-effective solutions that could potentially save India from incurring a loss of US$ 35 trillion due to unmitigated climate change over the next 50 years.[5]

However, participation in carbon markets requires the ability to navigate through a complex system with multiple stakeholders and an extensive monitoring process that makes generating and transacting credits a tedious task. The ecosystem is particularly hard to navigate for small- and medium-sized enterprises with limited expertise and resources looking to finance their decarbonisation journey through the carbon market. We are working to simplify the voluntary carbon market for all stakeholders involved with our suite of innovative products that act as a single point of access for all carbon market requirements.

Our tech-enabled platform provides user-friendly products and comprehensive support across the project lifecycle with a concerted focus on three aspects—trust, convenience, and transparency. Our products include a Carbon Project Eligibility Checker, a free and user-friendly tool that allows project developers to instantly assess if their green projects qualify to earn carbon credits and a Carbon Price Tracker that compiles data from various credible sources and bridges the information gap in the space by making average carbon credit price available freely. Furthermore, Carbon Market Access is a platform that connects project developers to buyers all over the world at the click of a button and is designed to maximise value and revenue for businesses. These products reinforce our commitment to making the market more transparent and accessible.

We work exclusively with businesses looking to decarbonise their operations or expand their pre-existing green initiatives by facilitating access to capital through carbon financing, and debt and equity markets. We operate across a wide spectrum of sectors, including waste management, plastics, sustainable agriculture, and electric mobility,

catering to businesses of all sizes, from NGOs and MSMEs to larger corporations. Some of our notable clients include the National Dairy Development Board (NDDB Mrida), EID Parry, and GPS Renewables.

In addition to creating the infrastructure to support the deployment of climate finance, Neufin also provides an ecosystem to help businesses accelerate project execution timelines through connections with the right advisors, project planners, and vendors. This ensures that businesses find a one-stop solution for their sustainability projects. We commit to meticulously understanding their business operations and requirements, a crucial underpinning in our ability to identify the right financial partner(s) for their distinctive needs.

Furthermore, we aim to enhance participation and transparency in carbon markets for businesses and financiers by offering market intelligence and advisory solutions, facilitating more informed and responsible carbon trading. Our team of experts help businesses and financiers make informed decisions that simplify the understanding of carbon markets. We cover questions ranging from project eligibility and commercial potential of a project to a more nuanced sectoral, pricing and policy

trend analysis. We are also committed to building intelligent products that democratise carbon financing—and our Carbon Eligibility Checker, Carbon Price Tracker, and Market Access tools are a reflection of this commitment.

At the same time, we endeavour to make a conscientious effort to partner with organisations that are dedicated to delivering a tangible societal impact on the ground. One such example is Partners in Prosperity (PnP)—an NGO that works to empower rural communities by introducing methods that encourage environmental sustainability and economic stability in agricultural practices. PnP, with the help of local communities, develops projects across the domains of agroforestry, local infrastructure development, and renewable energy, among several others. It then leverages the carbon market, through the sale of credits, to generate revenue from the projects, and uses the revenue to fuel a range of initiatives such as schooling and livelihood support, capacity building, and skill development. Thus, PnP and its work help empower the community and enhance their chances of securing long-term employment and livelihoods.

It is, however, important to acknowledge that while carbon financing can play a valuable role in advancing climate action, it is insufficient to keep up with the necessary pace of capital deployment required to address the global climate crisis. Acknowledging the multi-trillion-dollar financing gap, multiple financial institutions have made commitments to expand and diversify their green lending portfolio. These commitments are supported by policy measures that are prompting banks to make deliberate efforts to finance climate-positive projects.

To this end, debt markets can play a catalytic role in financing adaptation and mitigation for climate change but have remained largely untapped when it comes to financing green initiatives. However, their potential is immense. When debt financing incorporates social and environmental performance criteria, it ensures that projects align with sustainability principles, promoting job creation, social equity, and community well-being. Similarly, impact investing for climate action can drive a positive

change while considering social and environmental outcomes. We aim to build pathways that would enable capital providers to deploy funds with ease to support projects that directly benefit communities, such as renewable energy infrastructure and climate resilience measures.

By helping financiers direct their capital towards projects and companies that generate measurable and beneficial impact alongside financial returns, Neufin's platform can accelerate progress towards multiple overarching social goals such as job creation, community development, and social equity. We hope to play a vital role by leveraging our innovative solutions and products to enhance the well-being of people and foster inclusive economic growth.

III. Challenges to scale and recommendations for key stakeholders

One challenge that needs to be overcome is that Indian banks are wary of accepting carbon credits as collateral against commercial loans. This can be attributed to a limited understanding of the carbon markets as well as a lack of push from the government to, thus far, value and develop an understanding of carbon markets. The government can, therefore, enact supportive policies and regulations that recognise carbon credits as an eligible form of collateral and provide clarity on their treatment in loan agreements. Furthermore, frameworks can be created to incorporate carbon credits into the lending practices of financial institutions, such as developing standardised methodologies for assessing creditworthiness and establishing appropriate loan-to-value ratios.

There is also a lack of awareness and understanding among businesses about the potential benefits of transitioning to green practices and accessing climate finance. Even the businesses that are aware have limited access to affordable and tailored financial products for green projects, hindering the uptake of sustainability initiatives. Inadequate coordination and collaboration among financiers, government agencies, and businesses further contribute to the disjointed climate financing landscape, making it challenging to bridge the gap effectively. Furthermore, the regulatory framework governing climate finance is currently lacking.

While financial markets are increasingly making voluntary commitments to support climate action, it is important that the government guides the trajectory of such investments and sets up systems to address greenwashing concerns.

Moreover, Indian regulation has, so far, been slow-paced in mandating banks to make in-depth climate-related financial disclosures, compared to its Western counterparts in Europe and North America. But beneath the lack of regulation is a more fundamental barrier—despite the conversation around climate action evolving for decades, India still does not have a green taxonomy. Developing this framework would be hugely beneficial for private actors to define green investments, make more informed choices, enable market transparency, and create robust standards to tackle greenwashing.

IV. Conclusion

Today, there are many young companies committed to contributing to the world's climate mitigation and adaptation story; Neufin being one of them. We believe that the confluence of technology, policy, and finance is critical for encouraging innovative approaches for solving perhaps what is the most cardinal problem of our times. Such a collaborative approach would require financial institutions and the government to overcome their resistance to engaging with startups. It is only then that we can expect to see innovation at scale, unlocking positive environmental and social outcomes for both India and its citizens.

Neufin

Endnotes

1 Ministry of Environment, Forest and Climate Change, Government of India, https://pib.gov.in/newsite/printrelease.aspx?relid=128403.

2 Press Trust India, "India's green financing requirement estimated at 2.5% of GDP, says RBI Study," *CNBC TV18,* May 3, 2023, https://www.cnbctv18.com/environment/india-green-financing-requirement-gdp-rbi-study-16562451.htm

3 McKinsey Sustainability, "How Big Business Is Taking the Lead on Climate Change," https://www.mckinsey.com/capabilities/sustainability/our-insights/sustainability-blog/how-big-business-is-taking-the-lead-on-climate-change

4 Amanda Russo and Max Hall, "395 Million New Jobs by 2030 if Businesses Prioritize Nature, Says World Economic Forum," *World Economic Forum,* July 14, 2020, https://www.weforum.org/press/2020/07/395-million-new-jobs-by-2030-if-businesses-prioritize-nature-says-world-economic-forum/

5 Deloitte, https://www2.deloitte.com/in/en/pages/about-deloitte/articles/turning-point-press-release.html.

Leveraging Technology and Finance for Nature Positive Energy Transition

Madhur Jain and Gauraang Biyani

I. Agriculture as a key lever to achieve net-zero emissions

In the race to net-zero carbon emissions, much of the mainstream conversation is dominated by the energy transition—on how fast we can transition from fossil fuels to low-carbon energy sources such as solar, wind, hydrogen, and nuclear. However, this does not capture the full scale of the climate challenge. Burning fossil fuels is just one, albeit significant, contributor to greenhouse gas (GHG) emissions. Approximately 25 percent of GHG emissions result from agriculture, forestry, and land use (AFOLU) patterns, which will not be eliminated solely by diversifying the source of energy fuels beyond coal and petrochemicals.[1] Moreover, cleaner fuels will only *reduce* emissions; as opposed to removing the excess carbon content already present in the atmosphere as a result of industrial activity. Even with a 100-percent clean energy mix—a reality which remains several decades away—carbon emissions will continue to be generated. Achieving net-zero emissions targets thus requires going beyond reducing or avoiding emissions, to also removing carbon from the atmosphere.

Even after 75 years of independence, ~55 percent of Indians are engaged in agriculture and allied activities for their livelihood.[2] A "people-positive", "human-centric" energy transition cannot ignore the vast majority of the population, who are also the most vulnerable to climate change. >80 percent of Indian farmers are smallholders,[3] who cultivate plots of land smaller than one hectare in size. Most of these farmers still rely on the vagaries of the weather for their crop harvesting and production, and are most vulnerable to extreme weather events like droughts and floods.[4]

Especially since the "Green Revolution", conventional agricultural practices such as excessive tillage, flooding of fields, residue burning, deforestation, and overuse of chemical fertilisers have deteriorated soil quality in most of the country. Although these practices increased agricultural yields in many regions, it is increasingly clear that these gains are unsustainable. Nearly 30 percent of India's land[5] is considered

'degraded'. 'Soil Organic Content' of Indian soil is much lower than prescribed by experts, and it is increasingly deficient in several nutrients.[6] Smallholder farmers desperately seeking subsistence means of livelihood are more likely to engage in these unsustainable practices, which also lead to higher carbon emissions.

II. Varaha's solution: Leveraging technology and finance for nature

Varaha is building a technology platform to enable decarbonisation for smallholder farmers. We generate verifiable and additional "nature-based" carbon offset credits via best-in-class science and digital measurement, reporting and verification (MRV), working closely with smallholder farmers and land stewards to develop carbon avoidance and removal projects. Our growing portfolio of projects includes:

i) Regenerative agriculture, which encompasses practices like zero-tillage, crop diversification, cover cropping, crop residue incorporation; all of which are applied based on specific soil and crop type;

ii) Agroforestry, a land use method involving planting combinations of trees and bushes on farms and commons lands;

iii) Mangrove restoration, which refers to the restoration and protection of natural wetland ecosystems to enhance their natural potential to serve as "blue carbon" sinks; and

iv) Biochar production, in the form of controlled burning of biomass in a process called 'pyrolysis'.

Varaha's end-to-end carbon project enablement model utilises farmers and communities' natural assets to avoid and remove carbon emissions while harnessing carbon market finance tools, such as forward pricing, to incentivise sustainable practices. Our data collection and ground data validation processes prove "additionality" at a farm level, through a farmer-held app and physical soil samples to collect ground-level

data, combined with highly sophisticated technologies like remote-sensing-based Machine Learning (ML) models and Light Detection and Ranging (LiDAR) to validate on-ground practices. Our calibrated models then precisely quantify GHG emissions to generate high-quality, durable carbon credits independently verified by third parties as per global best practices.

Varaha's community-centric and science-first approach has helped us become among the world's leading developers of nature-based climate solutions in a short period. We share the majority of revenue from carbon credit sales directly with our 100,000+ smallholder farmers and land steward partners. Our ongoing projects are spread over 1 million hectares across five countries (India, Nepal, Bangladesh, Kenya, Tanzania), and we are building deep networks across a further eight to nine countries. Apart from directly increasing incomes and reducing CO_2 emissions, our projects create a range of other benefits for the environment. For instance, our flagship regenerative agriculture project across seven states in the Indo-Gangetic plains is helping improve soil organic matter, reduce erosion, and improve water quality. The majority of credits from this project are carbon removal credits, signifying a positive contribution to reversing climate change.

III. Challenges to scale and recommendations for key stakeholders

Looking at the road ahead for nature-based solutions for carbon avoidance and removal, there exist some challenges to scale. In this respect, public policy and private sector market participants both have roles to play in overcoming these challenges.

Nature-based solutions are still an emerging sector within agriculture, and there is significant effort needed to build awareness by educating key stakeholders, including the government. Government and community mobilisers can thereby communicate to smallholder farmers about the long-term benefits of nature-positive, organic agriculture and agroforestry, particularly in light of the fact that there may be temporary declines in yields in the first 1-2 years (compared with traditional, chemical input-led farming practices). Most cultivators intuitively understand the long-term advantages of nature-positive, organic farming practices but are initially reluctant to shift their methodologies, citing income losses and uncertain yield as their main concerns. As the market for nature-based solutions matures, these concerns will begin to be addressed, as more project financiers enter as part of the carbon markets value chain to cover losses in the early years, and early pilots begin to demonstrate success.

Today, much of the demand for nature-based, carbon offset solutions is still in the international voluntary carbon market. This growing market is still at an early stage of its evolution, and price discovery mechanisms are maturing. As compliance markets emerge around the world, beginning with developing economies like the European Union and the United States, one expects greater and more stable demand for high-quality nature-based credits generated in India. For instance, Japan has included India in its list of partners under the Joint Crediting Mechanism (JCM), whereby Japan will finance emission reduction projects in India in exchange for carbon credits.[7]

Indian capital markets have still not fully embraced carbon offsets, mainly due to an understandably cautious policy approach. It is heartening to see the Central government taking concrete steps for establishing the domestic carbon and "green" credit markets, through the Carbon Credit Trading Scheme (CCTS) as part of the Energy Conservation Bill.7 Ensuring transparency, market integrity, and standardisation are vital for its success, and properly aligning the CCTS with India's Nationally Determined Contribution (NDC) goals and global climate standards is necessary to gain international recognition.[8]

In June 2023, a draft of the Green Credit Programme (GCP) was released, which outlines the implementation rules and structure for individuals, agricultural cooperatives, forestry enterprises and other entities with the potential to generate nature-based credits.[9] India is developing a national unified carbon market (ICM) where some sectors will be covered by a cap-and-trade compliance market and a voluntary market operating in parallel. India is currently fixing carbon emission intensity benchmarks and reduction targets for three years for companies in petrochemicals, iron and steel, cement, and the pulp and paper sectors. The companies in these sectors are also likely to be the first ones to trade on the country's carbon trading market from April 2025.[10]

This policy momentum should continue. Crucially, this should not be accompanied by restricting the sale of domestically generated credits in the international market; doing so would deprive Indian smallholders of a significant market opportunity and repeat the adverse consequences of the wheat export ban of 2022.[11] On the contrary, the government should actively encourage global and domestic investments in Indian nature-based solutions, particularly project financiers and "forward" credit purchasers. Indeed, in response to a letter, Rohit Kumar, Secretary General, Carbon Markets Association of India, stated that "the Government of India and the National ETS under Indian carbon market will not restrict Indian businesses' participation in international voluntary carbon market and export of Indian origin voluntary carbon credits in international market".[12]

At the same time, domestic end-buyer demand needs to be stimulated. Indian corporations must show more urgency, first adopting science-based targets for offsetting emissions and then taking concrete steps. Businesses should recognise this as an opportunity rather than a compliance-related obstacle. Companies with large land exposure (for example food and beverage, and textile companies) particularly have an opportunity to decarbonise their supply chains ("insetting"), while simultaneously reducing long-term costs, increasing the well-being of partner communities (namely, farmers), and enabling a range of environmental benefits. Policymakers could push for faster action by corporations to adopt nature-based offsetting strategies.

Other potential challenges to scale include difficulties in establishing land ownership and slow action by the government to give permission for these nature-based projects to be executed on "common" lands (forests and mangroves). Governments should ideally work hand-in-hand with farming communities and project developers to identify and remove administrative bottlenecks for potential nature conservation and market opportunities, in order to contribute to India's net-zero, food security and conservation goals.

Finally, market participants such as project developers and accreditors must recognise that for any industry, 'trust' is earned over time. Developers must insist on robust monitoring and transparent reporting of benefits such as farmer income and environmental metrics, and ensure active participation of farming communities in project design and benefit-sharing. Over time, this will build trust in an emerging sector with the potential to play a decisive role in a people- and nature-positive energy transition.

IV. Conclusion

As the effects of climate change continue to intensify, not only are the livelihoods of many Indians under threat but so is the food security of the rest of our population. Varaha's solution is one which addresses this urgent need to prevent declining soil quality and unsustainable agricultural practices while moving India towards its ambitious net-zero goals. At Varaha, we want to ensure that this fight against climate change prioritises the most vulnerable communities and places them front and centre, and with the combination of technology and private market innovation at the core of our business model, we aim to realise this vision.

varaha
Disrupting Carbon Footprint

Endnotes

1 Grand Challenges Breakthrough Energy, "The Five Grand Challenges," Breakthrough Energy, https://breakthroughenergy.org/our-approach/grand-challenges/

2 Department of Agriculture & Farmers Welfare Ministry of Agriculture & Farmers Welfare, *Annual Report 2022-23,* Delhi, 2022, https://agricoop.gov.in/Documents/annual_report_english_2022_23.pdf

3 "Nearly 70 percent of Indian farms are very small, census shows," *Business Standard,* December 9, 2015, https://www.business-standard.com/article/news-ians/nearly-70-percent-of-indian-farms-are-very-small-census-shows-115120901080_1.html

4 Sagarika Phalke, "India's Farmlands Vulnerable to Climate Change," Indian Institute of Technology Bombay, https://www.iitb.ac.in/en/research-highlight/india's-farmlands-vulnerable-to-climate-change.

5 Madhumathi D. S., "Almost 30 per cent of our land undergoing degradation," *The Hindu*, July 7, 2016, https://www.thehindu.com/sci-tech/energy-and-environment/%E2%80%98Almost-30-per-cent-of-our-land-undergoing-degradation%E2%80%99/article14474590.ece

6 Bhabani S. et al., "Soil health and its relationship with food security and human health to meet the sustainable development goals in India" *Soil Security,* no. 8 (2022), https://www.sciencedirect.com/science/article/pii/S2667006222000375

7 "Japan adds India to List of JCM Partners", Quantum Commodity Intelligence, 2023, https://www.qcintel.com/carbon/article/japan-adds-india-to-list-of-jcm-partners-12859.html

8 Press Trust of India, "Power Ministry Issues Draft Carbon Credit Trading Scheme," *Outlook Planet,* March 27, 2023, https://planet.outlookindia.com/news/power-ministry-issues-draft-carbon-credit-trading-scheme--news-414972

9 Nidhi Singal, "Indian government introduces draft for Green Credits, to reward environmental initiatives", *Business Today,* 2023, https://www.businesstoday.in/latest/economy/story/indian-government-introduces-draft-for-green-credits-to-reward-environmental-initiatives-387559-2023-06-29

10 Sarita Chaganti Singh, "India to set emission reduction mandates for 4 sectors, to start carbon trading from 2025", *Reuters*, 2023, https://www.reuters.com/sustainability/climate-energy/india-set-emission-reduction-mandates-4-sectors-start-carbon-trading-2025-2023-09-26/

11 "Ban of wheat exports may hit farm incomes," *Hindustan Times,* February 14, 2023, https://www.hindustantimes.com/editorials/ban-on-wheat-exports-may-hit-farm-incomes-101676297833825.html.

12 Ruchira Singh and Agamoni Ghosh, "India's national carbon market to seek links with international registries", *S&P Global,* 2023, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/063023-indias-national-carbon-market-to-seek-links-with-international-registries#:~:text=It%20sought%20%22to%20clarify%20that,Kumar%2C%20secretary%20general%2C%20Carbon%20Markets

Harnessing the Diverse Use Cases of Solar Energy

Lakshmi Santhanam and Balaji Lakshmikanth Bangolae

I. The large potential of solar as a renewable energy source

As we move towards adopting climate-resilient practices to achieve net zero emissions, in manufacturing industries, mobility and transport, circular systems and material innovation, we are also undergoing a fundamental shift in our use of energy sources—from fossil fuels to renewables, specifically solar energy. Interestingly, the cost of solar energy generation has declined by 300 percent in the past decade and we achieved parity with the cost of coal in 2016.[1] Ever since the adoption of Solar Photo Voltaics (PVs), renewable installations are rapidly exploding at a CAGR of 22 percent[2] and today we have more than 1 TW of solar panels installed worldwide,[3] with a projection to reach 7 TW by 2040 as per the International Energy Agency.[4] Furthermore, India has made striking progress in achieving 63 GW of solar PV installations cumulatively so far, of which 14 GW was installed in the year 2022 itself.[5] India can drastically cut down on its annual oil imports of US$120 billion with indigenous technology to develop solar-powered green hydrogen and solar-powered electric vehicles.[6]

One of the most significant challenges in solar energy generation is mapping the continuous movement of the sun, which restricts the peak generation period of solar panels to a limited amount of time (around midday). This has been partly solved by mechanical trackers that manually move panels throughout the day to face the sun. Today, the generation of solar energy is only confined to utility-scale plants and urban rooftops. The promise of solar is immense and to make solar energy the default, long-term and sustainable option for consumers, we need a focused innovation that can transform a wide range of products into a solar use case. For example, balconies, fences, benches, building facades, windows and automobiles can all be made into solar reflective surfaces offering not only a green output but also attractive unit economics.

II. Renkube's solution

At Renkube, our solution is two-fold:

i) Through our "Motion Free Optical Tracking" (MFOT) technology, we are building a tracking capability in our smart glass design, instead of adhering to a stationary solar panel structure. We have designed this smart glass with our proprietary AI algorithm, and the uniqueness of this solution is that once it is fixed to the solar panel, it remains completely stationary and can track the sun throughout the year without causing hotspots on the solar cells.

ii) We are exploring the possibility of converting any surface exposed to sunshine into a solar energy-generating unit, and thereby we aim to build efficient and sustainable renewable energy products.

Our customer value proposition for the commercial and rooftop solar segment is the prospect of tracker-like benefits for panels, with reduced capex. For example, a 100 MW solar project involving trackers bears an additional capex of approximately US$13 million[7] for an extra 20-percent energy gain. However, Renkube's MFOT technology offers the same benefit for an additional capex cost of US$5 million with reduced maintenance and overhead costs.

Interestingly, owing to the unique layout of our panels, Renkube panels are more suitable for Agri PVs, which enables dual usage of land for both agriculture and solar energy generation. Our Agri PV pilot in Telangana has demonstrated a 95-percent crop yield (during the Rabi season which occurs between November and April) in 100 percent of the land while, in comparison, only 50 percent[8] of the land can be used for crop growth with traditional solar panels. This has opened up the possibility of exploring solar energy production as an additional revenue stream for the farmer. This would involve the farmer leasing the land to solar developers who pay a nominal lease to the farmer (INR 30,000 per acre/per annum). This economic guarantee can make a large difference to the livelihoods of small and marginal farmers.

We believe our innovation comes at the right moment as India is rapidly expanding its solar footprint across various states. To achieve the ambitious renewable energy capacity targets, we need to not only focus on power generation in dry, arid landmasses such as Rajasthan, as this would place pressure on distribution lines and lead to wastage and power transmission losses. We can instead focus on making reliable power available in a distributed manner in every state, which can be achieved with solutions such as Agri PV. For example, to achieve 450 GW of renewables by 2030, we would need landmass the size of the state of Sikkim. Similarly, to achieve India's net zero carbon emissions pledge of 5,000 GW of renewables by 2070, the equivalent land mass required would be the state of West Bengal. AgriPV solution like ours would enable to achieve these renewable energy targets by promoting dual usage of land for both solar energy generation and catering to the needs of our agrarian economy. Our goal is to make this an economically viable development in multiple regions and micro-climatic conditions.

III. Challenges to scale

Renkube's innovation lies in the design of glass facilitated by our proprietary AI software. During the development of our early prototypes on a small scale, we faced obstacles working with small cottage industries in Firozabad, known as the glass hub of India. Communicating our new designs done in Computer Aided Design (CAD) to unskilled labourers posed a significant hindrance. Convincing them of the critical importance

of adhering to specified dimensions proved challenging, resulting in some valuable time lost. However, we ultimately triumphed over these obstacles through persistent efforts, exploring various manufacturing methods and making design adjustments.

IV. Recommendations for key actors

We are blessed that today, a supportive startup ecosystem exists in India, backed by Startup India's initiatives, numerous incubation centres, labs, and other infrastructure. However, there is a large need for patient capital for deeptech startups, provided by both the government and investors, to ideate, experiment, and develop deeptech hardware products that have higher capex requirements for manufacturing and longer gestation periods for commercialisation.

Specifically, we would urge the Government of India to consider the possibility of a CleanTech grant focused on solely renewable innovations such as solar PV, solar thermal, tidal, green hydrogen, and solar energy efficiency improvements. Our ecosystem could benefit immensely by establishing a CleanTech Ignition Grant similar to what we have called as Biotechnology Ignition Grants which led to a boom of biotechnology startups over the last two decades. While we have several incubation centres and dedicated labs focused on biotechnology, nanotechnology, electronics, integrated circuit (IC) development, and other innovations,

there is a pressing need for incubation centres specifically focused on solar innovations for the purpose of expediting rapid prototyping.

Finally, Agri PV is a promising field that helps to solve our food-energy nexus simultaneously. At the top-most priority, we need the central and state governments to collaborate and introduce regulatory frameworks and necessary policies for initiatives supporting the implementation of Agri PV. Installing an AgriPV structure entails an additional upfront cost of 5-10 percent to be incurred, in order to raise the solar panels so that farm machinery can be used underneath. While the farmer benefits from the value proposition of a guaranteed income by leasing their lands, the developers still hesitate to absorb the additional capital cost. Thus, with the right financial incentives from the government; the establishment of a local nodal agency, which would act as a bridge between farmers and developers; and the regularisation of land laws, which are often state-specific, AgriPV can be accelerated to transform the livelihoods of these farmers.

A massive scale-up of renewable deployment over the next few decades will require securing large land parcels, particularly for solar parks. To facilitate this transition, the Agri PV concept emerges as an excellent solution, allowing us to simultaneously harness land for both solar power generation and agriculture. However, the success of AgriPV relies on significant government support in three key areas: Solar policy, land policy, and farmer policy. Government support can come in the following ways:

1. Provide preferential feed-in tariffs for electricity generated from AgriPV installations.
2. Amend land policies to facilitate the adoption of AgriPV systems.
3. Ensure reliable and timely disbursement of solar lease income to farmers participating in AgriPV projects.

Furthermore, the government can promote distributed renewable energy generation to significantly reduce transmission and distribution losses, estimated at around 10 percent.[9] One effective approach, is to encourage

industrial owners to deploy solar installations on nearby available agricultural land through an open-access model.

To foster innovation in solar technology and drive down the cost of solar energy generation, government organisations like the Ministry of New and Renewable Energy (MNRE) can play a pivotal role. MNRE should consider providing substantial grants, upwards of INR 1 Crore, for deep-tech innovations in the solar sector, similar to support provided in sectors like Biotechnology and Electronics. Collaborations with internationally renowned organisations such as the National Renewable Energy Laboratory (NREL) in the United States of America and the Fraunhofer Institute for Solar Energy in Germany for research and development can further accelerate progress.

Moreover, government initiatives like the Confederation of Indian Industry's (CII) cross-industry collaboration programmes have demonstrated success.[10] Encouraging industries to collaborate with startups can foster rapid prototyping and the development of innovative solutions in the solar sector, contributing to the overall growth of renewable energy in India.

V. Conclusion

At Renkube, we want to become the technology providers who will accelerate the adoption of solar energy in India. Being a tropical country, India can harness the versatile use cases of solar energy products and can play a pivotal role in positioning India in the world energy roadmap. The vision of "One Sun One World One Grid" has been outlined in the COP26 to trade renewable energy, and, in this regard, India is well-positioned to become a renewable energy superpower.[11]

Endnotes

1 Michael J. Coren, "2016 was the year solar panels finally became cheaper than fossil fuels," *Quartz*, December 26, 2016, https://qz.com/871907/2016-was-the-year-solar-panels-finally-became-cheaper-than-fossil-fuels-just-wait-for-2017

2 Fraunhofer, *Photovoltaics Report, February 2023*, Freiburg, Fraunhofer Institute for Solar Energy Systems, 2023, *https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf*

3 Anthony Cuthbertson, "World passes 1TW of solar installations – enough to power the whole of Europe," *Independent*, March 17, 2022, https://www.independent.co.uk/tech/solar-power-renewable-energy-europe-b2036988.html

4 International Energy Agency, *World Energy Outlook 2019,* Paris, IEA, 2019, *https://www.iea.org/reports/world-energy-outlook-2019.*

5 Uma Gupta, "India installed almost 14 GW of solar in 2022", *pv magazine*, January 16, 2023, https://www.pv-magazine.com/2023/01/16/india-installed-almost-14-gw-of-solar-in-2022/#:~:text=India%20installed%20approximately%2013%2C956%20MW,%2C%20up%2047%25%20from%202021

6 "India's oil import bill doubles to $119 billion in FY22," *The Hindu,* April 24,2022, https://www.thehindu.com/business/Economy/indias-oil-import-bill-doubles-to-119-billion-in-fy22/article65350880.ece

7 Brittany L. Smith, et al., "*Photovoltaic (PV) Module Technologies: 2020 Benchmark Costs and Technology Evolution Framework Results*," The National Renewable Energy Laboratory, November 2021, https://www.nrel.gov/docs/fy22osti/78173.pdf

8 P. Santra, et al. *"Agrivoltaics Systems Study*", Central Arid Zone Research Institute, IF-January-2018.pmd (icar.org.in)

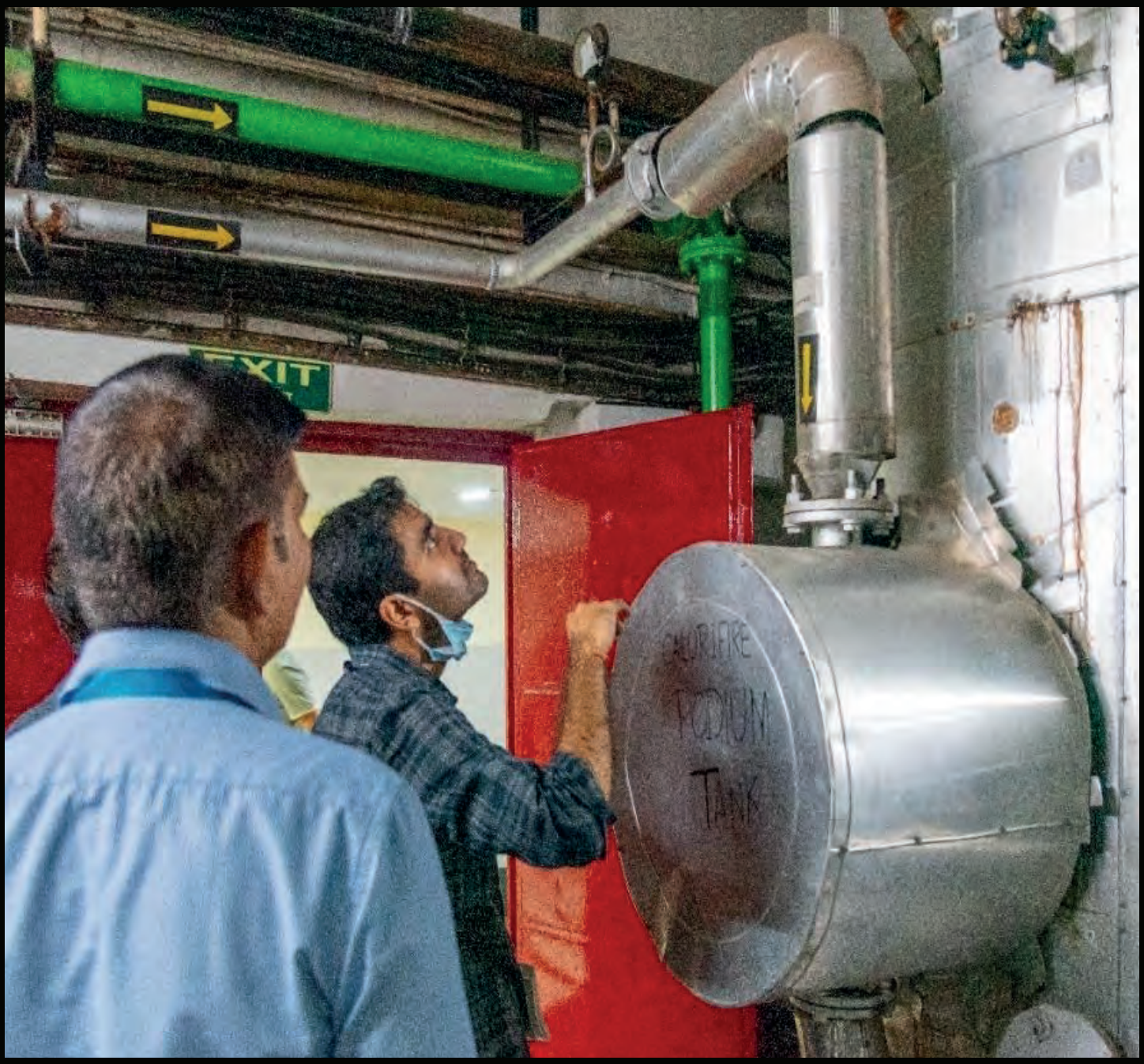
9 Sudharmma Vishwanathan et al., "Assessing enhanced NDC and climate compatible development pathways for India," *Energy Strategy Reviews,* Volume 49, (2023), https://www.sciencedirect.com/science/article/pii/S2211467X23001025#tbl1

10 "AICTE- CII Collaboration," All India Council for Technical Education, https://www.aicte-india.org/education/collaborations/moucii

11 "One Sun, One World One Grid': PM Modi calls for global solar grid at COP26," *Hindustan Times*, November 3, 2021, https://www.hindustantimes.com/india-news/one-sun-one-world-one-grid-pm-modi-calls-for-global-solar-grid-at-cop26-101635877791812.html

The Paradox of Cooling

Arjun Gupta and Rohan Batra



In our collective attempt to adapt to escalating global temperatures—a crisis of our own doing—we find solace in cooling solutions that ironically exacerbate the problem we aim to lessen.[1]

I The irony of thermal comfort in a warming world

As global temperatures rise, so does the demand for air conditioning. When combined with the atmospheric impact of refrigerants, the energy consumption associated with cooling represents one of the largest end-use risks to our climate.

India lies at the epicentre of this problem since a vast majority of the population lives in heat-stressed areas. India's 2021-2022 Economic Survey estimates that India could lose 5.8 percent of its working hours, equivalent to 34 million full-time jobs, to heat-stress events by 2030.[2] Furthermore, it suggests that cooling's share of the total electricity demand is expected to increase from 7 percent in 2020 to almost 20 percent in 2030.[3] Similarly, according to a recent United Nations Environment Programme (UNEP) and International Energy Agency report, India's cooling demand is expected to drive an additional 800 GW of power generation—more than twice the installed capacity in India today.[4]

This increase in power generation can impair efforts to contain climate change. The transformation of cooling efficiencies in India is a necessity, which will allow for increased productivity, positive health outcomes, and accelerated economic development without warming our planet and straining our grids. Yet, the transition towards more efficient, climate-friendly cooling solutions has been slow. High upfront costs deter the adoption of energy-efficient technologies, while market structures often fail to recognise, and hence price, the environmental externality of conventional energy use.[5]

The baffling truth is that the technologies to cool our future more sustainably already exist. Yet, they remain under-utilised, due to market failures, misaligned incentives, and outdated perceptions of cost.[6]

Although the Indian government has made commendable efforts to release an India Cooling Action Plan ("ICAP") that aims at reducing energy demand by up to 40 percent by 2037-38, the market is not moving fast enough to provide solutions at scale.[7] The primary reason for this lies in the prevailing business models, which are centred around the sale of equipment rather than reliable and cost-effective provision of the desired cooling service. This business model embeds inefficiency in cooling systems in all stages of a facility's lifecycle:

1. **Design and engineering:** Consultants often oversize cooling systems as their compensation is tied to installed tonnage capacity and the sales facilitated for equipment manufacturers. Since the actual performance of the cooling systems has little or no bearing on their fees, they do not practice careful, integrative design thinking to ensure and achieve substantial efficiency gains.

2. **Procurement and contracting:** Owing to a lack of information and imperfect decision-making processes, businesses typically prioritise upfront cost instead of lifecycle cost of ownership, and end up locking in years of inefficiency by not purchasing the best-in-class technology.
3. **Operations and maintenance:** These cooling systems then enter into a complex web of operational and maintenance inefficiencies. On-site operations teams stay busy conducting repair and breakdown activities while operating dynamic cooling systems based on thumb rules rather than analysing performance through data. Meanwhile, energy consumption, comfort and indoor air quality fluctuate without warning, causing financial losses and stress for both owners and occupants.

Due to these inefficiencies, new cooling technologies that have a much lower environmental impact but higher up-front costs, such as radiant and evaporative cooling systems, premium efficiency chillers using natural refrigerants, and thermal energy storage systems, face tremendous barriers to adoption at scale. As a result, facilities waste 30 percent or more of the cooling energy they consume and businesses struggle to maintain a green bottom line.

II. Smart Joules' Solution: Making sustainable cooling the default choice

To improve health, productivity, and well-being while mitigating the effects of climate change, Smart Joules is pioneering a new dominant business model for the cooling industry: Cooling-as-a-Service or "CaaS". CaaS applies the servitisation concept (shift from a product-centric to a service-centric business model) to the space cooling industry. Under the CaaS model, energy service companies such as Smart Joules, with specific expertise in cooling, offer sustainable, cost-efficient, convenient and high-quality cooling services at a fixed cost per ton-hour of cooling consumed by end-users. CaaS clients only pay for the cooling they consume, while the service provider takes full responsibility for design, financing, project execution, operations, and maintenance of the cooling infrastructure.

All the service provider's costs and margins are recovered through cooling service fees under long-term contracts. This model eliminates energy waste, since the focus shifts away from upfront cost to total cost of ownership over the lifetime of central cooling systems, which is more than 15 years. Significant energy efficiency gains and carbon reductions are achieved via efficient system design, deployment of the best available low-carbon cooling technologies, and continuous data-based operational optimisation with DeJoule – Smart Joules' proprietary living and learning system that leverages Internet of Things (IoT) and Artificial Intelligence (AI) platform technology.

Smart Joules provides CaaS models both for new facilities (called "JouleCOOL") and for existing facilities (called "JoulePAYS"), allowing any cooling-intensive building such as a hospital, hotel, mall, office building or factory, to de-risk adoption of energy efficiency and profit from climate action. These models are similar to how the power-purchase-agreement (PPA) or OpEx models fuelled the growth of the solar infrastructure industry.

The 'real world' impact of Smart Joules' technology has been substantial and quantifiable. Apollo Hospitals, the world's largest vertically integrated healthcare provider, is a case in point. Apollo has partnered with Smart Joules to reduce carbon emissions by 2,90,000 tons by 2033. This 10-year initiative covers 18 hospitals across India and leverages Smart Joules' interdisciplinary expertise for energy-efficient cooling and automation. In the brief period following the integration of the JoulePAYS solution into Apollo Hospitals, 235 energy conservation measures were implemented, resulting in forecasted savings of over 235 million kWh and INR 2 billion by 2030.[8] If we apply this technology to the numerous industries that have heavy cooling loads, there is potential to achieve more than 29 million tons of CO2 reduction within this decade.

III. Challenges in Scaling Smart Joules' Solutions

'The transition to sustainable energy is not merely a technological or economic shift, but also a societal one'.[9]

Resistance to change has prevented rapid uptake of Smart Joules' solutions, as it is challenging to lock down the first adopter. In addition, there is a complex and protracted decision-making process in large companies where seeking approval for a new technology necessitates every department to say yes, but any one stakeholder can say no, thereby blocking the adoption of the solution. Beyond market barriers, one of the most ubiquitous challenges confronting start-ups is the issue of financing. Uncertain creditworthiness on the part of customers, variability in contractual enforceability, and the relatively slow pace of the judicial system can increase the risk of long and pending payment cycles. Furthermore, infrastructure or project-level finance is scarce and expensive, particularly for small-scale projects such as centralised cooling systems in single facilities.

Yet, with every challenge, Smart Joules has learned, improvised and helped different stakeholders overcome their hesitations on implementing our technology. We have focused on consistently driving unprecedented results in terms of profitable carbon reduction for our clients while maintaining healthy project returns.

IV. Recommendations for key stakeholders

Inspired by the positive impacts of decarbonising cooling in India, Smart Joules has been actively engaging with not only the private sector but also non-profit organisations and government ministries. We have developed suggestions for catalytic action to transform India's cooling industry, drawing on our leadership positions within organisations such as Alliance for an Energy Efficient Economy (AEEE), the Sustainability Engine Foundation (aka "SusMafia"), Indian Electrical and Electronics Manufacturing Association (IEEMA) and through direct engagements with the Bureau of Energy Efficiency (BEE) and Ministry of Power. In

addition, we have formulated tailored recommendations for some of the key stakeholders to expedite the implementation of CaaS and ensure a successful transition to more sustainable cooling solutions.

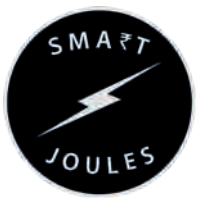
For example, our recommendation to central government agencies is to integrate CaaS into their India Cooling Action Plan (ICAP) implementation strategy, ensuring a sustainable approach to cooling solutions nationwide. Furthermore, adopting CaaS for a prominent upcoming central government project would serve as a powerful demonstration of its effectiveness, inspiring others to follow suit. Moreover, state-designated agencies can also play a crucial role in driving CaaS adoption. Including CaaS support in their strategic plans and actively promoting it through their networks can amplify its impact. In addition, think tanks and industry organisations should prioritise CaaS as a centrepiece in their cooling initiatives. Widely sharing CaaS concept notes and success stories will accelerate the adoption across various sectors.

Financing agencies can enable CaaS implementation by providing non-recourse debt facilities, which will lower financial barriers for adoption. Moreover, including energy efficiency as a loan condition for other businesses can incentivise energy-conscious practices, aligning with CaaS's sustainable objectives. Finally, real estate developers can contribute significantly by committing to pilot at least one CaaS project within their portfolios. This can showcase their commitment to eco-friendly solutions and can set a precedent for sustainable cooling practices within the built environment.

V. The way forward

Needless to say, in an era of increased global warming, cooling is no longer a luxury but a fundamental necessity, particularly in countries prone to high temperatures, such as India. Smart Joules' technology offers cooling solutions that are simple, substantial, profitable and accessible, making real the idea that energy efficiency can bring the benefits of environmental sustainability, economic savings, and societal wellbeing.

Smart Joules' early success is emblematic of a broader upcoming energy efficiency revolution, where a company's earnings are tied to the actual energy savings realised. This paradigm shift not only aligns economic incentives with environmental goals but also removes the barrier of high upfront capital expenditure for higher efficiency technologies. We hope to have the ability to transform the future of energy and make energy efficiency the default choice, one Joule at a time.



Endnotes

1 Valérie Masson-Delmotte et al., *Global warming of 1.5°C,* IPCC, 2019, https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

2 Ministry of Finance, *Economic Survey 2021-22,* Government of India, 2022, https://www.indiabudget.gov.in/budget2022-23/economicsurvey/index.php

3 Ministry of Finance, *Economic Survey 2021-22*

4 United Nations Environment Programme and International Energy Agency, *Cooling Emissions and Policy Synthesis Report,* 2020, https://www.unep.org/resources/report/cooling-emissions-and-policy-synthesis-report

5 *Cooling Emissions and Policy Synthesis Report*

6 Amory Lovins, "How Big Is The Energy Efficiency Resource?," *Environmental Research Letters,* Volume 13, Number 9 (2018), https://rmi.org/insight/how-big-is-the-energy-efficiency-resource/

7 Ministry of Environment, Forest & Climate Change, *India Cooling Action Plan,* New Delhi, Government of India, 2019, https://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

8 BioSpectrumIndia, " Apollo Hospitals partners with Smart Joules to curb carbon emissions," Biospectrum, https://www.biospectrumindia.com/news/98/23224/apollo-hospitals-partners-with-smart-joules-to-curb-carbon-emissions.html

9 Mark Z, Jacobson, "Review of solutions to global warming, air pollution, and energy security," *Energy & Environmental Science*, Issue 2 (2009), https://pubs.rsc.org/en/content/articlelanding/2009/ee/b809990c

Circularity in Action: Transformative Technology for a Sustainable Future

Ezhil Subbian and Sanjeevani Marcha

I. The importance of sustainable food systems

The United Nations (UN) predicts that the world's population will reach 10 billion people in 2057, which is likely to intensify the pressure on worldwide resources.[1] India, in particular, faces significant growth challenges as it targets to evolve into a developed economy by 204. On the one hand, there is rising consumer demand from the largest global population, and on the other hand, there is heavy reliance on fossil fuels and unsustainable manufacturing practices.[2]

As the pressure to sustain this rising population grows, there is an urgency to ensure long-term food security as a part of the effort to build climate resilience. Sustainable food systems are essential for our planet's well-being and the health of its inhabitants. As the global population continues to grow, ensuring access to nutritious and safe food while minimising environmental degradation is paramount.

II. String Bio's solution: Using fermentation to create a circular loop

In response to this escalating demand for sustainable agricultural solutions and long-term food security, String Bio has developed a pioneering technology that utilises advanced microbial fermentation to convert the greenhouse gas (GHG) methane into valuable products, which can be utilised across various industries, ranging from agriculture, human nutrition to animal feed and personal care sectors.

By harnessing the converted methane, String Bio's technology can be seamlessly integrated into agricultural practices, bolstering crop productivity, enhancing crop health and decreasing methane output from agriculture. For example, rice is the dominating cereal crop in Asia with more than 90 per cent of the world's rice occupying 140 million hectares located on the continent.[3] It also means that Asia is responsible for large scale methane emissions from this crop production. Rice production contributes to around 10-13 percent of annual methane emissions and its total GHG output puts it on a par with international aviation.[4]

String's agricultural input, CleanRise, is an innovative bio-stimulant that creates a healthy bioactive complex enabling robust vegetative growth. Its use case in paddy cultivation has shown exceptional results, namely in demonstrating yield increases of up to 40 percent from field trials across a variety of crops.[5] In rice, there are even more marked and significant results: The use of CleanRise results in a 33-percent increase in grain yield in treated crops. In addition, the use of CleanRise decreases methane and nitrous oxide emissions up to 60 percent and 40 percent respectively over untreated crops.[6] This has resulted in a disruptive solution that not only increases rice yield and return on investment (ROI) for farmers but also reduces GHG emissions from agriculture. If we are able to implement this product in ~10 percent of global paddy fields, we can achieve 23 percent of the COP26 per annum methane reduction target, and its implementation in ~50 percent of global paddy fields can surpass this target.[7]

Furthermore, the production of high-quality animal feed using String Bio's platform is an ethical and sustainable solution to meet the growing demand for nutritional sources in industries such as aquaculture, poultry and swine farming. String Bio's solution exemplifies the principles of circularity, ensuring the efficient utilisation of resources. By actively reducing methane emissions and repurposing it for valuable applications, String Bio's process minimises waste and environmental impact. This circular approach aligns with the ethos of sustainable development and promotes a harmonious relationship between industry and the environment.

Moreover, the scalability and adaptability of String Bio's technology make it a compelling asset in the pursuit of a green economy. The solution can be implemented on various scales, from localised operations to large-scale industrial applications. This adaptability allows for seamless integration into existing infrastructures.

In addition to environmental benefits, String Bio's solution brings about positive social impacts, particularly for local communities. Farmers and marginalised groups stand to gain improved livelihoods and economic opportunities. By integrating String Bio's technology into their operations, farmers can improve their ROI, enhance their crop resilience, and contribute to sustainable agricultural practices. This inclusive approach strengthens local economies, empowers communities, and fosters social equity.

III. Challenges to scale and recommendations for key stakeholders

While innovative technologies building capacity for climate resilience hold immense potential, scaling up these solutions presents several challenges that need to be addressed. Substantial investments in infrastructure, research, and development are imperative to unlock the full potential of these technologies. Collaborative efforts between governments, private enterprises, and research institutions are critical to providing the necessary financial resources and expertise to expedite the scaling process of deep tech startups.

Furthermore, navigating complex and fragmented regulatory frameworks poses additional challenges that must be overcome through streamlined processes and intergovernmental collaboration. To accelerate the adoption of solutions such as String Bio, support from policymakers is crucial. Advocacy for favourable policies and regulations that promote sustainable technologies and provide incentives for their implementation is necessary.

Policymakers must recognise the value of these new-age technology solutions in addressing energy challenges and achieving climate goals.

Moreover, addressing the financial constraints and investment challenges associated with scaling up the technology is crucial, through government or private grants, venture capital or debt financing. In this vein, innovative funding mechanisms, public-private partnerships, and international cooperation can play a pivotal role in mobilising the necessary resources. By fostering an enabling environment for investment and innovation, key actors can support String Bio's journey towards widespread adoption.

Finally, today, the positioning of the products manufactured from this platform is exclusively based on value from manufacturing and product use benefits to end users. The establishment of a robust carbon framework (locally and globally) would enable further monetisation through the generation and sale of carbon offsets in the process, which can add further value creation from these solutions.

Conclusion

Advanced biomanufacturing is a critical and growing sector that is driving the change from petrochemicals to sustainable biobased solutions. India can play a key role in enabling biomanufacturing globally and enable this transition. String Bio's journey serves as an illustration of how innovation can push for sustainability and propel the transition towards a low-carbon economy. With a commitment to circularity, String Bio not only optimises resource utilisation but also contributes to the resilience of our food systems, paving the way for a more sustainable future.

As innovators like us continue to forge ahead, expanding our horizons and refining our approaches, it becomes evident that a robust ecosystem of support and incentives across the value chain is essential. Through this collective drive, we have the potential to usher in a new era where technology innovation translates into measurable environmental and societal impact.

String Bio

Endnotes

1 Tanuvi Joe, "World Population to Reach 10 Billion by 2057: What that Means for the Planet," *Green Queen*, June 19, 2021, https://www.greenqueen.com.hk/world-population-2057/.

2 Pallavi Nahata, "India Needs to Grow 7.6% Annually To Be An Advanced Economy by 2047: RBI," *BQ Prime*, July 17, 2023, https://www.bqprime.com/business/india-needs-to-grow-76-annually-to-become-an-advanced-economy-by-2047-rbi-bulletin

3 Chunling Sun, Hong Zhang, Lu Xu, Ji Ge, Jingling Jiang, Lijun Zuo and Chao Wang, *20 m Annual Paddy Rice Map for Mainland Southeast Asia Using Sentinel-1 SAR Data*, Earth System Science Data, 2022, *https://essd.copernicus.org/preprints/essd-2022-392/essd-2022-392.pdf.*

4 Ali Mohammadi et al., "Joint Life Cycle Assessment and Data Envelopment Analysis for the benchmarking of environmental impacts in rice paddy production," *Journal of Cleaner Production*, no. 106, (2015), https://doi.org/10.1016/j.jclepro.2014.05.008.

5 University trials with VIT Vellore, Chennai (publication under review)

6 University trials with VIT Vellore, Chennai (publication under review)

7 University trials with VIT Vellore, Chennai (publication under review)

Harnessing Wastewater for Global Climate Resilience

Mansi Jain

I. Background to the water crisis

Today, freshwater is scarce: 21 Indian cities are predicted to run out of groundwater in 2023,[1] and 54 percent of the country faces severe water stress.[2] Moreover, this situation is not unique to India; other emerging markets also face similar challenges. Not surprisingly, the bulk of the effects of climate change will be manifested through increasing water scarcity. Since water is critical to our survival, the need for developing sustainable systems to conserve this resource has never been as pressing as it is today.

By treating and recycling wastewater at scale, we could directly meet 60–70 percent of urban water needs and prevent the pollution of freshwater resources.[3] Moreover, the benefits extend beyond conserving water. Recycling treated wastewater can actively contribute to reducing greenhouse gas emissions. For instance, in 2021, the exclusive use of recycled treated wastewater for irrigation alone had the potential to reduce India's greenhouse emissions by 1.3 million tons.[4] Unfortunately, we are far away from being able to accomplish this today. While water treatment plants are becoming more ubiquitous, nearly 75 percent of these plants are dysfunctional even though customers spend significant amounts of capital to maintain their daily performance and minimize inefficiencies.[5]

Our team has interviewed hundreds of plant owners as well as experts, from institutions such as the WASH Institute, to gain a deep understanding of the root causes for water treatment plant inefficiencies. The insights that we gathered pointed towards the fact that the data, expertise, and systems to manage these facilities effectively do not exist on site. On site, operations are managed by low-skill operators who typically learn about problems retrospectively, sometimes weeks after they first arise and often lack the technical knowledge to address these issues. As a result, not only do plant owners incur huge expenses to achieve minimal output, but they also face the risk of penalties and shutdowns since these plants become non-compliant by government operational standards. Moreover, these dysfunctional plants not only consume excessive energy but also produce treated water that cannot be utilised, leading to the continued pressure to extract fresh water (a finite resource) for industrial and commercial use.

II. Digital Paani's Solution: Technology to unlock wastewater's potential

We envisioned a solution that would drive operational excellence in these wastewater treatment facilities by empowering low-skilled operators with the expertise needed to manage water operations efficiently. Digital Paani is an Internet of Things (IoT)-enabled integrated operations platform for wastewater management. We use software and sensors in each unit operation to remotely automate, monitor, and manage facilities while driving complete visibility through communication channels such as WhatsApp.

Our solution manages the entire operations of a plant, based on its actual design and real-time needs, and ensures that every aspect of the plant, including its pumps and blowers, the operator tasks, chemical dosing, or even basic maintenance actions, are executed as per the right technical guidance. We also have a centralised control unit that monitors our target wastewater plants 24 hours a day and 7 days a week. This unit coordinates directly with the operations team to ensure that tasks

are being carried out correctly and on time. Therefore, Digital Paani is not only a technology product but also an end-to-end operational management solution to ensure that wastewater plants are managed well and customers achieve their desired efficiency outputs.

One example of our solution making an impact on plant operations is how we address a drop in the pH levels in the core reactor, which results from a complex biological reaction. Typically, operators on site do not have the technical ability to resolve this, and personnel outside the site have little visibility until a few weeks pass and the issue begins to impact treated water quality. In such a situation, Digital Paani's technology has the ability to detect, diagnose, and send out appropriate instructions to correct the malfunction instantly, such as feeding more

biological matter to the reactor. Our technology also has the ability to even remotely modify the automation of the equipment, such as the pumps, to ensure the right balance of sewage in the reactor.

This new method of operations has so far shown positive and consistent results, transforming dysfunctional plants into compliant assets while improving water quality and reducing operational costs for customers by up to 41 percent. In another example, one of our plants was 14 years old and prone to frequent issues as a result of operational mismanagement. We detected and supported the operational team in solving several issues such as poor backwash practices that prevented filters from working, choked pumps, ineffectual chlorine dosing, and failed automation. We also streamlined the end-to-end operational process and recommended energy-saving measures at key points of inefficiency. As a result, the plant is now treating and recycling 100 percent of its sewage water. At the same time, operational breakdowns have decreased by 86 percent and energy needs have also reduced by 33 percent, removing at least as much CO_2 as 5,500 mature trees. There are 85,000 such facilities in India alone, and this number is growing at 8 percent on an annual basis.[6,7,8]

III. Obstacles to scale

This journey has not been without its challenges. As with any new business, we had to ensure that the product development pace kept up with customer expectations even as R&D costs and timelines were uncertain. We also had to deliver our services, deploy our product, and onboard customers effectively while maintaining a lean team, to conserve cash flow. What has helped us address these challenges was the learnings shared by other early-stage founders in the climate tech space. Additionally, we realised that individual action cannot help manage the water crisis alone; it will take the combined efforts of civil society, the private sector and the public at large to tackle this problem. This means, that even though the government is already making efforts to promote eco-friendly manufacturing to bolster the growth of startups building for a net-zero future, there are a number of further reforms that would add significant value to the sector.

IV. Recommendations to key stakeholders

One example of such a reform is changing procurement norms to enable startups developing sustainable products to receive access to B2B contracts without having to navigate extensive tendering processes. Additionally, while there are more innovation-oriented mentoring programmess and grants being launched, these initiatives largely focus on providing funding to startups for the first few pilot projects only. However, to truly scale up operations, companies need access to long-term capital to invest in building their core technology, strengthening their teams, and developing a differentiated value proposition. We believe that grant funding and other similar programmes should assist companies in scaling up their operations rather than just focusing on individual pilot projects.

V. Conclusion

Our solution therefore presents a remarkable opportunity to aid India in its efforts to reduce carbon emissions and move towards a cleaner and more sustainable future. In five years, we hope to be paving this path by removing as much sewage from water bodies every day as 78 Olympic-sized pools, saving enough fresh water every day to meet the needs of 700,000+ people, and removing as much carbon from the atmosphere as 7 million mature trees. Our eventual vision is to make a substantial and lasting positive impact on our planet's well-being, and we invite every building and factory looking to be a sustainability leader to join us on this journey.

Digital Paani

Endnotes

1 Mihir Sharma, "India's man-made water crisis threatens more cities," *Gulf News*, June 29, 2023, https://gulfnews.com/opinion/op-eds/indias-man-made-water-crisis-threatens-more-cities-1.64857827

2 Tien Shiao, Andrew Maddocks, Chris Carson and Emma Loizeaux, "3 Maps Explain India's Growing Water Risks," World Resources Institute, https://www.wri.org/insights/3-maps-explain-indias-growing-water-risks

3 Krishna Rao, "Wastewater and Faecal sludge reuse- to address India's water and food scarcity," *Times of India*, October 22, 2021, https://timesofindia.indiatimes.com/blogs/voices/wastewater-and-faecal-sludge-reuse-to-address-indias-water-and-food-security/

4 "Reusing treated wastewater in irrigation could've reduced greenhouse gas emissions by 1.3 million tonnes in 2021: Study," *Energyworld,* March 28, 2023, https://energy.economictimes.indiatimes.com/news/renewable/reusing-treated-wastewater-in-irrigation-couldve-reduced-greenhouse-gas-emissions-by-1-3-million-tonnes-in-2021-study/99063487#:~:text=New%20Delhi%3A%20Reusing%20treated%20wastewater,main%20drivers%20of%20climate%20change

5 "70% of Indian sewage treatment plants dysfunctional: Javadekar," *Times of India*, November 21, 2014, https://timesofindia.indiatimes.com/india/70-of-indian-sewage-treatment-plants-dysfunctional-javadekar/articleshow/45231410.cms

6 *CPCB report on CETPs and STPs, 16/09/2020*, India Environment Portal, September 16, 2020, *http://www.indiaenvironmentportal.org.in/content/468537/cpcb-report-on-cetps-and-stps-16092020/*

7 Central Pollution Control Board, *National Inventory of Sewage Treatment Plants*, New Delhi, 2021, *https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==*

8 "Water & Sludge Treatment," *Fortune Business Insights*, July 2022, https://www.fortunebusinessinsights.com/water-and-wastewater-treatment-market-102632

Building a Digital Infrastructure Platform for the Electric Grid

Sunil Talla, Mushtaq Ahmed, Vamsi TP, and Neeraj Sansanwal

I. The need for structural reform in the power sector

We have two compelling narratives that define India's energy transition story.

On one side, India has a vision of achieving 500 GW of renewable energy capacity by the year 2030.[1] This ambitious goal, growing at 15 percent per year, signifies an important shift towards sustainable power generation. To meet these objectives, various subsidies are being provided to attract capacity additions tility-led tenders and Commercial & Industrial Open Access (C&I) projects. Every corporate is accelerating their energy transition plans through C&I Open Access markets including CTU (Central Transmission Utility) grids. New sectors are also emerging along with the focus on building a low-carbon economy and achieving net-zero emissions by 2070. For example, there are many startups and corporates building innovative climate technologies to address the decarbonisation of hard-to-abate sectors, green chemistry to eliminate the use of hydrocarbons in the Fast Moving Consumer Goods (FMCG) product value chain, and green hydrogen to replace the use of chemical burners in manufacturing industries.

On the other side, Discoms are already facing challenges today by way of accumulated losses amounting to US$6.11 billion[2]. Over the last 10 years, public discoms have remained stressed due to higher levels of Aggregate Technical, Commercial, and Collections (ATC&C) losses compared to regulatory norms—the nationwide average of this loss being 24 percent; low tariffs in relation to their cost of supply (resulting from low cash collection from consumers due to poor quality of supply).[3] Corporates looking for Open Access solution will further worsen the financial position of the Discoms and significantly affect the asset utilisation levels (thermal generation and transmission) which are already on the lower side.

As we delve into this compelling narrative, we must look at solutions that can support and balance both sides. The energy transition story of India cannot afford to overlook the realities of Discom financials that confront us today. At EdgeGrid, we have chosen to make the Discoms and the Grids sustainable while leading this data-driven energy transition.

Broadly speaking, the energy transition focus has disproportionately favoured large and global companies, leaving the crucial 'last mile' market unattended, ignoring over 65 percent of the sector's market share. In the pursuit of a climate-friendly economy, this last-mile market must not be ignored, and the transition must be both impactful and profitable. As electrified two-wheelers (2W) and three-wheelers (3W) are set to play their role in the energy transition, with fleet operators and commercial vehicles following suit, the sheer number of users (and therefore demand for electric power) at the last mile will grow exponentially. Furthermore, simply adopting electric vehicles (EVs) is not enough to effectively combat climate change; it is crucial that EV mobility should be powered by clean and sustainable energy sources (renewables rather than the coal-fired grid).

The way that consumers interact with the grid is fundamentally changing, from bilateral power purchase agreements and state-driven power transmission to democratised and delicensed market access to energy, where commercial, industrial and residential players can buy, sell and produce their own energy. This creates an opportunity for a new solution to emerge: One that lowers the costs for end customers, slows down the pace of climate change by integrating renewables into the grid, and, most importantly, creates new financial opportunities for consumers with respect to sustainability and energy profits.

II. Edgegrid's Solution: Data-driven integration of Distributed Energy Resources (DER)

At EdgeGrid, we are building the digital infrastructure for the distributed grid to accelerate the path towards a zero-carbon future and cater to the last-mile customer, through a data-driven energy transition. Historically, grids were designed around centralised power generation and uni-directional power flows, primarily fuelled by fossil fuels. However, with renewable energy costs plummeting, the emergence of electric vehicles, and with the rise of Distributed Energy Resources (DERs), a paradigm shift is taking place.

EdgeGrid's vision centres around the belief that "software can eat carbon," implying that building a data-layer and a smart software solution to manage the energy will make the grid and costs to the consumers more sustainable and efficient.

DERs such as onsite solar, wind and battery storage, as well as EV chargers, and microgrids, are increasingly prevalent for industrial businesses to achieve their energy management goals. The costs of DER have fallen sharply in recent years, so that these resources outcompete conventional energy sources, even without policy incentives. For discoms, as more industrial customers link their energy usage to increasingly sophisticated energy management systems, discoms can tap into these resources to meet peak demand or unusual spikes in electricity usage, and use this new flexibility to help balance electricity supply and demand as the share of large scale solar and wind power (which can be intermittent) grows.

EdgeGrid aims to capitalise on this industry shift to create a data and market platform that can aggregate, manage, and optimise DERs effectively, so that these assets can collectively contribute to the electric grid and power last-mile customers more efficiently. There are four key thematic areas which EdgeGrid focuses on:

1. **Distributed and decarbonised energy**: EdgeGrid's breakthrough lies in empowering local communities to collaborate with the grid and their utility to generate and manage renewable energy. By enabling access to rooftop and distributed solar plants at the locations where it is profitable to the grid and consumers, the platform allows users to produce and consume energy independently of the grid and allows them to transact with each other in the form of energy credits. This democratisation of energy is data-driven.

2. **Demand flexibility or virtual battery**: Demand flexibility allows consumers to adjust their energy consumption based on real-time pricing and grid conditions. EdgeGrid's digital infrastructure enables a virtual battery concept, where energy consumption can be optimised to match supply, reducing the need for physical energy storage and improving grid stability.

3. **Energy storage or real battery**: Energy storage solutions are vital for storing excess energy generated from renewable sources and ensuring a reliable power supply during periods of low generation. EdgeGrid aims to integrate real battery solutions into the energy ecosystem to enhance grid resilience and reduce dependence on conventional power sources during peak demand.

4. **Grid modernisation**: Grid modernisation is crucial to accommodate the changing dynamics of India's energy landscape. EdgeGrid's digital infrastructure will help upgrade and optimise the existing grid infrastructure, allowing for seamless integration of DERs and improved energy distribution.

III. Challenges to scale and recommendations for key stakeholders

1. **Regulatory framework for seamless renewable integration:** To accelerate the energy transition, it is imperative to untangle the complex web of regulations that currently constrain the seamless integration of renewables. EdgeGrid advocates for a progressive regulatory framework that not only encourages but also incentivises the adoption of renewable energy sources. Such a framework should not rely on subsidies or incentives; instead, it should be rooted in market principles that harmonise sustainability and profitability within the energy sector.

2. **Discom engagement as anchors of the energy transition:** The active engagement of discoms with other key stakeholders in the energy transition ecosystem is severely lacking. EdgeGrid is committed to fostering collaboration with discoms, enlightening them about the numerous mutual benefits this transformation offers and, at the same tim,e co-develop solutions that can help Discom financials as well as accelerate energy transition for the entire grid.

3. **Financing distributed energy resources (DERs):** The last-mile market often lacks the high creditworthiness required to attract investments from financial institutions and banks. However, with the appropriate interventions from various stakeholders, these projects can become financially viable. EdgeGrid is actively working to establish a market framework that addresses the bankability of distributed energy resource projects.

These challenges, once overcome through concerted efforts and strategic initiatives, will pave the way for a smoother and more rapid transition to a sustainable and inclusive energy ecosystem.

IV. Conclusion

EdgeGrid's digital infrastructure for the distributed grid aims to democratise access to clean energy and empower consumers in making sustainable choices. As renewable energy becomes increasingly dominant and consumers seek sustainable choices, the distributed grid represents the future of energy. By enabling cost reduction, promoting renewable integration, and empowering commercial, industrial and residential consumers, EdgeGrid is paving the way for a human-centric energy transition at the last mile, fostering a sustainable energy future for all.

edgegrid

Endnotes

1 "India to achieve 500 GW renewables target before 2030 deadline: RK Singh," *Energyworld*, September 25, 2023, https://energy.economictimes.indiatimes.com/news/renewable/india-to-achieve-500-gw-renewables-target-before-2030-deadline-r-k-singh/103927527#:~:text=The%20country%20has%20a%20target,the%20fastest%20in%20the%20world

2 Arjun Joshi, "DISCOMS aggregate loss soars to INR 502.81 billion in FY2021", Mercom, https://www.mercomindia.com/discoms-aggregate-loss-soars-to-502-billion-in-fy-2021

3 Prasanth Regy, Rakesh Sarwal, Clay Stranger, Garrett Fitzgerald, Jagabanta Ningthoujam, Arjun Gupta, Nuvodita Singh, "*Turning Around the Power Distribution Sector: Learnings and Best Practices rom Reforms*", NITI Aayog, RMI, and RMI India, 2021, https://www.niti.gov.in/sites/default/files/2023-02/Electricity-Distribution-Report_030821.pdf

The Power of Energy Cloud Solutions

Ankit Mittal and Kavin Aadithiyan

I. The pressures on the current electric grid

India is currently the third-largest energy consumer in the world.[1] In the next two decades, India's energy demands will necessitate the creation of a power infrastructure equivalent in scale to the European Union's existing power system. While energy use has doubled over the last two decades, India's per capita energy use is still lower than half of the world average, implying that the latent energy demand is high and transmission of electricity to end-consumers is inefficient. Furthermore, over 270 million people are set to join India's urban population over the next two decades, which will bring about a requirement of significant additions across electricity generation to distribution.[2]

India's electric grid sector has been undergoing a massive transformation on the back of a sustained rise in renewable energy. While renewables have economic and environmental advantages, as an energy source, they are intermittent in nature and require energy storage systems to effectively integrate into the current electricity infrastructure, manage peak power loads, and balance the grid stability. Centralised energy storage is usually in the form of i) spinning turbines, so that power generation companies can ramp up production if demand spikes; or ii) coal or diesel backup generators that can be fired up quickly. However, these approaches are either costly, polluting, or both.

By contrast, clean energy storage solutions such as batteries and pumped hydro-storage systems are already being used globally, while other storage technologies, such as flywheels, supercapacitors, and green hydrogen, are in the early stages of development. More than US$5 billion was invested in Battery Energy Storage Systems (BESS) in 2022; and the global BESS market is expected to reach between US$120 billion and US$150 billion by 2030, more than double its size today.[3]

Batteries represent a wide range of technologies that can provide numerous benefits to the grid. Importantly, a single battery can provide several services over its life. For example, a battery system can be installed for the primary purpose of shifting peak electricity consumption from a time when the distribution or transmission is congested to a

time when capacity is available. This may only require the battery to be dedicated to this service for a few hours each day. When that battery is not providing this peak shifting service, it can be used as a firming or flexibility resource to smoothen renewable generation to better match demand.

However, building standalone storage is broadly unviable because most of the requirement is for short-duration storage, within four hours each day. Cloud storage is therefore the best solution, as utilities do not have to build out storage on their own and can access it on a pay-per-use basis, which also allows them to scale up quickly.

II. Sheru's Solution: Building affordable and easy access to energy storage

Sheru, an innovative player in India's energy sector, is revolutionising the way that energy is managed and utilised. Sheru initially worked on providing battery swapping infrastructure as a service to three-wheeler (3W) electric rickshaws. When the COVID-19 pandemic struck, and mobility services came to an abrupt halt due to lockdown measures, we wanted to think of an alternate use for the Electric Vehicle (EV) batteries that were lying idle. We developed the idea of a virtual cloud storage network (which later became NetBat), wherein the idle batteries could be virtually aggregated to provide energy storage facilities to utilities.

This is in keeping with a broader move towards Industry 4.0, which is a digital transformation of manufacturing processes and products, such as Artificial Intelligence (AI), the Internet of Things (IoT) and the Cloud. By promoting connectivity across battery assets, this allows for the opportunity to monitor these assets through data analytics and insights, which can lead to cost savings and a cleaner, more flexible and resilient power supply.

NetBat, a flagship product of Sheru, is a network-based solution that plays a vital role in enabling the seamless integration of energy storage into India's evolving energy ecosystem. It empowers distribution companies and grid operators to leverage the power of energy storage

on a pay-per-use basis. It also provides a revenue stream to owners of the battery assets, making EVs more affordable and in turn driving forward the transition to electric mobility. The effects of our solution have been particularly transformative in the lives of those at the bottom of the pyramid, namely the drivers of the 3W e-rickshaws, as they can access a cleaner and cheaper form of mobility, with a lower total cost of ownership.

The key characteristics of NetBat include:

i **Energy Storage Optimisation**: By leveraging advanced analytics and intelligent algorithms, it maximises the efficiency and optimum usage of energy storage systems, allowing distribution companies to dynamically manage energy demand and supply, reducing reliance on conventional power sources and promoting clean energy integration.

ii **Grid Stability and Resilience**: NetBat enhances grid stability and resilience by providing energy storage capacity during peak demand periods or grid emergencies. It enables smoother integration of intermittent renewable energy sources and helps mitigate the challenges of grid intermittency, ensuring a reliable and stable power supply for consumers.

iii **Demand Response and Flexibility**: NetBat facilitates demand response programmes by coordinating the discharge of energy storage systems based on grid signals and pricing signals. This flexibility allows for the optimisation of energy usage and reduces strain on the grid during periods of high demand, contributing to cost optimisation and improved grid reliability.

III. Challenges to scale and recommendations for key actors

Owing to its intermittent nature, integrating renewables sources to the electric grid poses a significant challenge to the overall grid stability. A sharp increase or decrease in power production would adversely impact

the grid, and there needs to be solutions that can absorb or release energy instantly as needed. With Time of Day (ToD) tariffs set to play a greater role in the coming years, analytics that can provide data on energy storage systems would unlock significant value for utilities.

Other challenges persist including the need for regulatory support and a favourable administrative framework. Policymakers must incentivise the deployment of energy storage solutions such as NetBat by providing financial incentives, streamlining regulatory processes, and establishing clear guidelines for grid integration. In the same vein, there are a number of startups working on clean energy and mobility in India. For these to reach their potential, there has to be greater risk and growth capital available for these companies to grow and scale. Stakeholder engagement and collaborative partnerships among relevant actors in the ecosystem will be key in addressing these challenges. To this end, Sheru aspires to establish alliances with distribution companies, technology providers, and financiers with the aim to promote trust, encourage knowledge sharing, and foster cooperation among the stakeholders in order to ensure a smooth energy transition.

IV. Conclusion

India is experiencing rapid economic growth 75 years after its independence. But along with this economic growth comes the burden of rising carbon emissions. In response, India has set an ambitious goal: To derive 60 percent of its electricity from renewable sources, aiming to decouple economic growth from emissions.[4] The Sheru team is dedicated to supporting India's quest for a cleaner, greener, and more sustainable growth path by leveraging our energy cloud technology to integrate renewables into the power grid.

SHERU

Endnotes

1 Ministry of Petroleum & Natural Gas, Government of India, https://pib.gov.in/PressReleasePage.aspx?PRID=1809204

2 International Energy Agency, *India Energy Outlook 2021*, Paris, IEA, 2021, *https://www.iea.org/reports/india-energy-outlook-2021*.

3 "Enabling renewable energy with battery energy storage systems," McKinsey & Company, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/enabling-renewable-energy-with-battery-energy-storage-systems.

4 Michael Safi, "India plans nearly 60% of electricity capacity from non-fossil fuels by 2027," *The Guardian*, December 22, 2016, https://www.theguardian.com/world/2016/dec/21/india-renewable-energy-paris-climate-summit-target

Building Climate Resilience Through Advanced Analytics

Abhilasha Purwar

I. The growing need to price climate risk

The rising volatility in financial markets, with respect to natural disasters and extreme weather events such as floods, wildfires and droughts, is linked to the accelerated pace of climate change. In the past few decades, such eventualities were rarely factored into financial models in long-term asset portfolios, as the relevant data to make key decisions was either sparse or simply unavailable.

The predictability of our natural environment, which we once took for granted in our personal, social, financial, and business decisions, no longer remains valid. Across the globe, we earlier operated under the assumption that there has been consistent access to energy and natural resources for the last-mile consumer, but recent events have shaken these assumptions. For example, during the summer of 2022, industrial production in China's Sichuan province suffered due to reduced water levels in the Yangtze River.[1] Furthermore, in July 2023, floods devastated various regions in India, causing significant damage. Key rivers such as the Beas, Yamuna, and Brahmaputra reached record-high levels, and

Himachal Pradesh alone suffered losses exceeding US$1 billion, with several bridges, highways, and homes damaged.[2] Similar flood, heatwave, and wildfire effects were observed in July 2023 in Northeastern United States (US), South Korea, Türkiyé, Canada, and Greece.

These large-scale catastrophes provide a glimpse of the alarming outcomes of climate change on urban and rural infrastructure, investor confidence in real estate portfolios, climate risk for insurance companies and the stability of communities. For operating businesses, climate change-related risks are forecasted to cause supply chain disruptions, increase operational expenses, and lead to loss of capital, penalties and more. Companies will also have to grapple with the devastating impacts that climate change has on workforce health and safety. The financial and human costs incurred due to the myriad impacts of the environmental crisis far outweigh any short-term benefits of long-standing practices. There is therefore a need for solutions that predict and analyse the likelihood and intensity of a natural disaster before it unfolds, through data intelligence and quantitative modelling.

II. BlueSky Analytics' solution

Blue Sky Analytics has developed a platform, technology, and infrastructure to offer consistent, reliable and accessible climate intelligence to global clients in the financial, insurance, real estate, government and non-profit sectors. Our business model focuses on three main areas: i) Asset Monitoring, ii) Carbon Markets and iii) Climate Risk Analytics, supported by digital public goods and technology infrastructure. Our journey has involved collaborating with various stakeholders to enhance user experiences and decision-making processes.

During our first year, we focused on gathering satellite data and utilising Artificial Intelligence (AI) to build prediction models through algorithms, such as our products SpaceTime™ and Climate Data Hub. Our solution enables users to visualise various environmental and climate data, including forest carbon stock, river water levels, and seven-day wildfire forecasts. The Asset Management System provides relevant intelligence for specific assets, such as power infrastructure, transmission lines,

oil pipelines, or degraded land for carbon credits. Clients can access this data via Application Programming Interface (APIs) at their preferred frequency and resolution.

III. Challenges to scale and recommendations for key actors

One of the key challenges that we have faced is the issue of monetisation, in other words, securing clients who are willing to pay for this climate risk intelligence. For instance, our technology is equipped to predict floods, simulate rainfall, estimate water levels in rivers and provide advance warning for potential disasters. While this technology can prevent accidents, support timely evacuations, and offer valuable information to lenders and insurers, the question arises as to who should bear the cost of this critical intelligence. Banks require specific data subsets for underwriting loans and insurance companies seek one-year-out probabilities. Governments tend to have a long and protracted process to administer public infrastructure projects, which limits swift implementation. Achieving the requisite monetisable parameters necessitates an elaborate model generating multiple additional parameters, all of which, if accessible to the public, could save countless lives.

In contrast, we've developed another product concurrently, with the same engineers and input cost, which has already been adopted by multiple customers and is experiencing consistently high growth. It has the potential to generate sustainable revenue, allowing us to enhance its performance, quality, and reliability year after year. What is clear is the impact on climate, society, and human lives these datasets can have, but these products are often underfunded and underutilised behind paywalls.

Many such innovations are often funded through grants, yet the continuity of such endeavours without repeatable and assured sources of revenues remain challenging. The outcome is numerous abandoned and outdated projects by various governments, space agencies, non-profits, consulting companies and CSR teams—which are all siloed and underutilised.

Developing technology for the planet is crucial, but the pathway, scale, and potential for achieving sustainable revenue for climate risk providers remains unclear.

Therefore, the importance of flexible grants for various climate innovations is evident, whether within nonprofits, for-profit organisations, Small or Medium Enterprises, or solopreneurs. However, grants often come with obligations like open-source or CC-BY licenses. Furthermore, to ensure the longevity of these products, projects, and services, maintenance is crucial. This includes user engagement and asset improvement, necessitating the exploration of sustainable revenue streams. Therefore, flexible grant funding becomes crucial and should be allocated to climate tech startups for early innovation and R&D, allowing for technology experimentation and the establishment of product-market fit. Also, increased support in the Seed to Series A/B stages can go a long way in addressing these constraints.

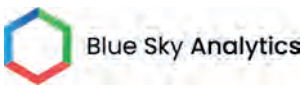
Additional challenges encompass educating customers to navigate their needs, preferences, and biases, which can be time intensive. Scaling up satellite data acquisition is another hurdle; smaller acquisitions yield costly products with subpar service, while larger ones demand superior customer service, pricing, and faster turnaround times. Moreover, ensuring data and intelligence credibility is a complex task, given ongoing debates about data accuracy and model reliability, alongside controversies in climate risk, carbon markets, and ESG metrics. It's worth noting that these challenges aren't exclusive to our organisation but are shared across the sector.

To encourage proliferation of such climate tech enterprises, showcasing examples of climate tech companies that have achieved sustainable growth and revenue will inspire and guide other startups and founders as well. Adequate government support can provide the right policy signal and demonstrate a commitment to climate intelligence, ultimately driving the private sector's transition to adopting these critical solutions. While the final buyer with the right paying capacity is this industry is the Banking, Financial Services, and Insurance sector (BFSI) sector, the government can act as the logical first buyer to induce trust, establish

credibility, educate the private sector, and accelerate its adoption. Policies or compulsory reporting guidelines for banks and insurers can significantly help drive adoption and impact.

IV. Conclusion

Developing climate risk intelligence to combat climate change and environmental degradation is a large challenge that demands diverse capital sources—public, private, grant, equity, and debt—and human expertise at a massive scale, to transform existing systems and create new ones globally. Collaboration between nonprofit and for-profit entities is vital. Flexible grants for early R&D and prototyping are crucial, enabling monetisation in the case of for-profit models. If executed well, innovative funding mechanisms for companies building climate risk analytics and intelligence can drive long-term value creation and lead us to a low-carbon future.



Endnotes

1 "The Yangtze River is shrinking as drought disrupts the world's No. 2 economy," *NPR,* August 19, 2022, https://www.npr.org/2022/08/19/1118369938/the-yangtze-river-is-shrinking-as-drought-disrupts-the-worlds-no-2-economy

2 C Krishnasai, "India: Himachal rains caused loss of $1.2 billion, will take a year to redevelop, says CM Sukhu," *WION,* August 16, 2023, https://www.wionews.com/india-news/india-himachal-rains-caused-loss-of-12-billion-will-take-a-year-to-redevelop-says-cm-sukhu-626061

II

Powering the future: Opportunities for private capital in the electric grid sector

Priya Shah, Himanshu Sharma, and Waroon Chhabra

I. Introduction to climate tech as an investment theme

India's ambitious climate commitments for 2030 and its net zero emissions target for 2070 call for a need for rapid decarbonisation. The transition to a low-carbon future will require the combined efforts of various stakeholders—corporates, industry, policymakers and startups—each playing a unique role in gradually eliminating fossil fuels, petrochemicals, and hydrocarbons from the value chain. Importantly, climate is a multidisciplinary field, which affects all aspects of societal and economic well-being—ranging from energy utilisation, mobility, and material innovation to food security, waste management and water conservation.

At Theia, our investment mandate focuses on mobilising capital towards climate solutions that use scientific innovation to build scalable technologies for large, underserved markets. These include broader areas such as circular economy, carbon credits, and alternative materials. For instance, our portfolio company, Varaha, enables smallholder farmers to generate carbon credits via nature-based solutions based on advanced remote sensing analytics and soil carbon modelling. Canvaloop, another portfolio company, converts agricultural waste such as hemp, pineapple and banana, to textile fibre and yarn to sell to global garment manufacturers. Metastable Materials uses a chemical-free battery recycling process using patented carbothermal reduction technology, to extract rare earth metals from end-of-life electric vehicle (EV) batteries. AltM Bio extracts lignocellulose from agricultural waste to utilise in applications such as green chemistry formula inputs in the FMCG, beauty and cosmetic industries.

However, in this essay, we shine a spotlight on a core climate tech sector that Theia maintains a significant footprint in—the electric grid—and the need for private capital to spearhead its growth, encourage the integration of renewables and EV demand, and modernise existing power infrastructure through advanced technology, so it can effectively support the transition to net zero.

II. Revolutionising India's electricity infrastructure for sustainable growth

India ranks as the third-largest energy consumer in the world with consumption doubling over the last two decades.[1] Yet, the per capita consumption of energy is lower than half the world average.[2] This proves that there is a higher demand for latent energy and inefficient transmission of electricity to last-mile consumers, particularly those residing in remote areas that are subject to frequent power outages. There are 417 GW of energy assets deployed in India by power utility companies, but only 39 percent are fully utilised, owing to factors such as poor quality of assets (such as distribution transformers), inadequate planning, and transmission losses faced by distribution companies (discoms). mainly state-owned power distribution companies).[3] These issues are further exacerbated by inadequate infrastructure and lower asset utilisation, leading to energy inefficiencies and escalating supply costs for last-mile consumers.

Below is a snapshot of some of the thematic areas where we, as a venture capital (VC) firm, see opportunities for capital injection to further encourage the decarbonisation of the electric grid:

a) Smart Grids

With an increase in demand for power and the proliferation of distributed assets, the existing electric grids have reached their maximum capacity. Going forward, India needs to rely on a new kind of grid that can automate and manage the increasingly complex needs for electricity. A smart grid is a holistic solution that employs a broad range of information technology resources, allowing existing and new gridlines to reduce electricity waste and energy costs. Smart grids also offer the advantage of integrating high levels of renewable energy into the electric grid. If a solar Photo Voltaic (PV) system and industrial electricity consumers are integrated through smart grid communication technology, and the solar PV system switches off due to weather interruptions, the smart grid can automatically switch to the non-renewable source. Moreover, smart grids can provide discoms with continual, real-time information and monitoring of how distributed renewable systems are operating.

Our portfolio company, Probus Smart Things, operates in this segment, providing distribution substation analytics through the Internet of Things (IoT) as well as smart meter design for power generation companies using Radio Frequency mesh technology.[4] Several government-sponsored programmes, including Smart Grid Forum, the India Smart Grid Task Force, and the National Smart Grid Mission have also made it possible for India to transition from centralised to decentralised power generation.

b) Battery Energy Storage Solutions

India is expected to produce 350 GW of renewable energy in this decade, which is 400-percent higher than the capacity added between 2010 and 2020.[5] This makes it essential to add balancing sources like clean energy storage systems to maintain grid stability.

Battery energy storage systems of the future can support the grid 24x7 by providing frequency and voltage support, offsetting the use of diesel sets. This kind of application allows for power back-up, peak load shaving, frequency and voltage regulation, and selling power back to the grid. Furthermore, these energy storage systems can be integrated with solar panels and Electric Vehicles (EVs) for grid stabilisation to use the Time of Day (ToD) charges during the off-peak demand period. Notably, the Ministry of Power recently notified such ToD tariffs for electricity from 2024 onwards.[6]

In terms of market size, the cumulative potential for battery storage in India is estimated at 601 GWh by 2030, with a CAGR of 44.5 percent in annual demand, reaching 162 GWh by 2030,[7] compared with the 2022 demand. The EV segment is anticipated to contribute the most to this market size (64 percent).[8] To this effect, in our portfolio, EdgeGrid and Sheru are two companies that demonstrate significant potential in this space. They are both building technologies for distributed energy resources (DER) and cloud energy storage, which will support the grid to respond quickly to changes in demand and supply with greater flexibility and control in the management of power systems.

c) Virtual Power Plants

Virtual Power Plants (VPP) are cloud-based power plants that aggregate generators, electrical loads, and storage units to work as a single entity. By leveraging information and communication technologies and IoT, VPPs ensure optimal power generation and enable the integration of renewable energy into the grid. They also enhance grid reliability and address power outages and blackouts, frequency and voltage imbalances, and network stability issues. In India, VPPs can effectively cater to the changing power needs, particularly with the increase in rooftop solar systems. Utilities can use them to optimally manage the amount of power consumed and generated. India still has a high proportion of rural areas, and deploying VPPs can indirectly expand access to electricity in such areas by enabling the deployment of more renewable resources.

However, the rise of VPPs in India will depend on vast consumer adoption of DER assets in residential, commercial, and industrial locations, as well as a ready wholesale market for consumers to transact in energy usage.

Moreover, discoms in India would need to display a willingness to partner with DER aggregation software platforms, which prove that collating hundreds of aggregated commercial-industrial customers' behind-the-meter storage systems (including solar, electric vehicle chargers, and batteries) can lead to improved reliability and performance of power distribution. For instance, Sheru has partnered with BSES Rajdhani to launch India's first vehicle-to-grid station.[9] Through this initiative, Sheru will utilise its bidirectional battery swapping station to provide interchangeable batteries whilst also assisting BRPL in meeting its power requirements during peak demand periods by utilising the battery capacity of swapping stations as a DER.

III. Future outlook for private capital in this sector

Large-scale adoption of smart grids, battery energy storage solutions, and VPPs holds significant potential for revolutionising India's electricity infrastructure. Several privatisation and delicensing measures to encourage external liquidity into the power sector—such as the formation of the Real-Time Energy Market and the Green Term Ahead Market (GTAM) by the Indian Energy Exchange, and the move to spur the transaction of Renewable Energy Certificates (RECs)—have paved the way for access to clean energy and efficient power distribution for the last mile. In 2022, the Indian government also notified the Green Energy Open Access Rules, which reduced the open access transaction limit to 100 kW (from 1 MW),[10] which allows smaller customers to purchase and trade power, and not have it be limited to large bilateral power purchase agreements.

In our view, VC activity in this space has been limited, mainly because conventional VCs view this sector as highly regulated, along with long sales cycles with utilities, and its deep tech nature with longer scale-up and gestation periods. Historically, only large infrastructure funds have actively invested in the electric grid sector. Nevertheless, technological innovation, particularly in software around the concept of 'digital decarbonisation', and in modalities such as artificial intelligence (AI), machine learning (ML) and energy blockchain, if mobilised at the start-up level (and following in the footsteps of United States-based climate tech funds focused on this thesis), will be hugely attractive to catalysing mainstream VC capital into this sector. Furthermore, effective collaboration among other capital providers such as banks, philanthropic (risk-free) capital, industrial players, university R&D labs, and the government, is also essential to underwrite early product risk, which is where learnings from the successful initiatives in the solar and EV sectors could be particularly useful.

India's ambitious plans for a net zero transition by 2070, and the increasing focus on renewable energy, make today an ideal time for VCs to explore investment opportunities in the electricity grid infrastructure space. VCs need to recognise the transformative potential of this sector and take a more proactive approach to support early-stage companies and crowd in the first few cheques, which will kickstart the growth of private investment in this sector. By doing so, they can effectively contribute to building a more efficient, technology-enabled, low carbon and resilient electricity grid for the last-mile in India.

Theia Ventures, established in 2021, is an early stage climate tech fund based in India, which invests in transformational technologies working towards decarbonisation. The fund invests in climate sectors ranging from smart grid to electric charging infrastructure to carbon markets and biomaterials.

THEIA VENTURES

Endnotes

1 Ministry of Petroleum and Natural Gas, Government of India, https://pib.gov.in/PressReleasePage.aspx?PRID=1809204

2 International Energy Agency, *India Energy Outlook 2021,* Paris, IEA, 2021, https://www.iea.org/reports/india-energy-outlook-2021.

3 Ministry of Power, Government of India,"Power Sector at a Glance ALL INDIA,", https://powermin.gov.in/en/content/power-sector-glance-all-india

4 "Probus Smart Things raises $500,000 in funding led by Unicorn India Ventures," *The Economic Times,* August 19, 2021, https://economictimes.indiatimes.com/tech/funding/probus-smart-things-raises-500000-in-funding-led-by-unicorn-india-ventures/articleshow/85439162.cms?from=mdr

5 "Why India Inc needs energy storage solutions and how it can do it," *The Economic Times,* February 26, 2023, https://economictimes.indiatimes.com/industry/renewables/why-india-inc-needs-energy-storage-solutions-and-how-it-can-do-it/articleshow/98244833.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

6 "Consumers can now save upto 20% in electricity bills with the new tariff rule," T*he Economic Times,* June 23, 2023, https://m.economictimes.com/industry/energy/power/india-to-cut-power-tariff-during-solar-hours-raise-for-peak-hours/articleshow/101209500.cms.

7 "Opinion: Energy storage: Powering India's energy transition and decarbonisation drive," *EnergyWorld,* November 2, 2022, https://energy.economictimes.indiatimes.com/news/power/opinion-energy-storage-powering-indias-energy-transition-and-decarbonisation-drive/95248974

8 "Opinion: Energy storage: Powering India's energy transition and decarbonisation drive"

9 "BSES Rajdhani and Sheru collaborate to launch India's first vehicle-to-grid Station," *mint*, May 24, 2023, https://www.livemint.com/companies/news/brpl-and-sheru-launch-india-s-first-vehicle-to-grid-station-boosting-green-mobility-and-fortifying-power-grid-11684925494413.html.

10 "Power Ministry Notifies New Amendments to Green Energy Open Access Rules," *Saur Energy International,* May 24, 2023, https://www.saurenergy.com/solar-energy-news/power-ministry-notifies-new-amendments-to-green-energy-open-access-rules.

Cultivating climate resilience: Agritech solutions

Abhilash Sethi

During the Industrial Revolution and the modern era, the world population increased from 600 million in 1700 to 8 billion in 2023[1] as economic output increased and sophisticated medicine became available. Due to tremendous economic and population growth, two additional agricultural revolutions took place to feed the expanding population. The British Agricultural Revolution[2] of the 18th and 19th centuries used farm machinery, crop rotation, and commodity trading to increase agricultural productivity, and the Green Revolution[3] of the mid-20th century used hybrid seeds and fossil-derived fertilisers and pesticides.

To feed the world's expanding population, agricultural land (cultivated and pastureland) was increased from 1.1 billion ha in 1750 to 4.87 billion ha in 2016.[4] This equates to about 50 percent of the world's habitable land obtained by clearing forests and grasslands for agriculture. With increasing human prosperity, the demand for animal protein started increasing. Today, the total percentage of agricultural land, directly or indirectly, used for livestock production is about 77 percent while contributing to only 18 percent of the world calorie supply.[5] Furthermore, biofuels have been gaining appeal as a sustainable and greener alternative to fossil fuels and presently account for 8 percent of global cultivated land and 11 percent of grain output.[6] There is undoubtedly a tremendous strain on global land resources in order to attain food and energy security.

The world population has expanded by a factor of four[7] in the last century, reaching 8 billion, and is expected to reach 10.4 billion[8] by 2080. This burgeoning population will need more calories, better nutrition, and protein from our increasingly strained resources. Smallholder farmers in Asia and Sub-Saharan Africa will play a critical role in solving future food demands, and there is a huge opportunity there to boost productivity and efficiency.

To make matters more daunting, we are facing a climate crisis. Due to the massive consumption of fossil fuels, the global temperature has been continuously rising since 1920,[9] and the United Nations has been advocating awareness on environmental issues and the use of renewable energy since 1980. Meanwhile, countries like China and India emerged as economic powerhouses in the late 20th century and relied on readily

available fossil fuels to supply their expanding energy needs. To avert further environmental damage, the world must migrate to alternate renewable energy sources as soon as possible. Furthermore, agriculture accounts for around 18.4 percent[10] of worldwide CO2 emissions (14 percent in India)[11], which has to be lowered through sustainable farming practices.

Agriculture can provide a solution to food and energy security while also protecting the environment. We are on the cusp of another agricultural revolution that will use digital and biotechnologies to maximise farm productivity in a sustainable manner.

(i) The first step is to freeze the agricultural footprint and stop destroying forests.
(ii) Increase agricultural productivity on the same land by improving low-yield farms in a sustainable manner with optimised application of inputs.
(iii) The global animal protein supply should shift to lower-carbon meats like shrimp, poultry, and fish[12]. This move can potentially free up farms and pastureland[13].
(iv) Instead of burning crop waste, which contributes 3.5 percent[14] of global CO2 emissions, we should use it to manufacture second-generation biofuels, green feed, and other products.
(v) Between harvest and retail, around 13 percent[15] of worldwide food output is squandered. We must work towards plugging this leakage in order to sustain our food systems.

It must be mentioned that renewable energy's growth is debatable. The additional area needed for energy crops, infrastructure and transmission lines may harm the environment and local population[16] further. Hence, the solution to food security and energy security has to be, and can be, achieved together.

The India playbook

India has around 179 million ha[17] of cultivated land, accounting for more than 10 percent of the world's cultivated area, with a cropping intensity

of 1.41[18]. When compared to the global average cropping intensity of 1.13, India farms 25 percent more land per year than its global peers. Low yields, on the other hand, lead to wasteful exploitation of Indian farmland, as seen in the comparison below. Furthermore, due to supply-demand mismatches and infrastructure challenges, India loses anywhere between 5-15 percent[19] of its crops in the post-harvest value chain. On top of that, crop waste burning, and non-judicious application of chemical inputs have been causing serious damage to the environment.

Omnivore has backed a portfolio of agricultural startups to address many of these challenges and build the future of agriculture and food systems. Below are a few of the startups that are making agriculture, profitable, resilient and sustainable.

Artificial Intelligence (AI)-enabled horticulture platform Fasal sells a plug-and-play farm sensor that analyses 18 different variables (weather, crop, soil etc.) to provide farmers with correct irrigation and predictive pest advisory, increasing farm productivity by 10 percent while reducing water and pesticide consumption by 20-40 percent, thereby lowering farming's carbon footprint. Additionally, Fasal has saved 70 billion litres of water in its years of operation, which has had a huge environmental impact considering agriculture uses 80 percent[20] of India's surface water. Although India is a major producer of fruits and vegetables, our

contribution to global fruit commerce is less than 1 percent[21] due to food safety concerns. Fasal's ability to reduce pesticide use boosts India's export potential for sustainably farmed high-quality crops.

Niqo Robotics[22] develops AI-powered spot-spray technology that sprays crop protection, fertilisers, and herbicides selectively at the plant level, reducing soil spraying. Crop protection and herbicide chemical use are reduced by 60 percent and 90 percent, respectively, using Niqo's targeted spraying. This saves farmers money and dramatically reduces chemical exposure in the farm ecology.

Agrizy is creating a marketplace for agri-processing units in order to improve their capacity utilisation and suit the customised processing needs of end clients.[23] India processes less than 10 percent of its agricultural output, with the vast majority of the processing being primary in nature.[24] When compared to 40 percent in China, 70 percent in Brazil, and 80 percent in Malaysia,[25] this figure appears little, resulting in substantial agricultural waste in India ranging from 5 percent to 15 percent across various commodities.[26] Agrizy strives to expand the country's whole agri-processing sector while also assisting in the reduction of food waste along the value chain.

Bioprime[27] is an agribiotech firm that creates biological products from India's massive flora and microbial population. India benefits geographically from 15 agroclimatic zones, each with its own variety of plants and microbes. SNIPR (for plants) and BioNexus (for microbes) platforms have been developed by Bioprime to investigate these living beings and synthesise signalling molecules for the development of bio-stimulants, bio-nutrition, and bio-control products. Their products have lowered farm chemical inputs by about 30 percent while improving plant health and pest resistance, leading to a 50 percent increase in output. Bioprime has lowered carbon footprints on farms and allowed farmers to grow more crops on the same land.

Loopworm is an alternative protein company that produces sustainable proteins from Black Soldier Fly larvae and Silkworm pupae for shrimp, fish, poultry, and pet food.[28] Their products are intended to partially

replace fish meal, krill meal, and soymeal. Fish meal and krill meal are made from oceanic fish such as sardines, mackerels, anchovies, krill, and squid, whereas soybeans and maize are cultivated on arable ground with potable water. Sustainable ingredients, such as insect proteins, can allow these natural resources to regenerate or be used directly as food for humans, resulting in a more sustainable food system. Also, entomophagy has recently gained popularity and given their low feed conversion ratio of about 1.7, insects could become a viable alternative source of animal protein for human consumption in the near future.[29]

altM manufactures biomaterials at scale and assists industries in reducing their supply chain carbon footprints through industrial innovation.[30] They are committed to developing high-value products by better utilising agricultural waste. Every year, India generates 350-990 million tonnes of farm waste, the majority of which is burned, causing environmental damage.[31] AltM fractionally breaks down these lignocellulosic biomasses into cellulose, hemicellulose, silica, and lignin, which are subsequently converted into high-value products for the cosmetics, pharmaceutical, and packaging industries. This will help India reduce its imports of petrochemicals, imported wood-derived compounds, and biomaterials. The sector will benefit from some policy help in aggregating agri-waste raw materials from fragmented and dispersed rural farms.

Similarly, there are multiple other startups, along with the government and corporates, who are working in the agriculture sector trying to solve various issues.

Key recommendations

However, there are certain challenges that startups are facing that require policy support.

(i) Hardware technology startups have trouble scaling because of slow adoption rates and price-sensitive customers. To overcome this inertia,

the government could accommodate upcoming tech in the agri input subsidies plan. It can potentially help agritech startups scale up and, eventually, lead to better utilisation of subsidy and even its overall reduction.

(ii) Working capital is a big consideration for agriculture startups. The comparatively longer lead time of the industry makes it even trickier. Some policy support for the B2B agriculture startups such as credit guarantee schemes and invoice discounting would benefit them in business growth and diluting equity only for non-working capital-related growth purposes.

(iii) We are seeing startups coming up in the biomaterials and biological inputs space, a sign of the maturing sector. These deeptech startups generally work in overlapping spaces covered under various ministries of the Government of India and are facing challenges in navigating through the regulations of each ministry. An interactive portal or single window system to ease this for startups will be useful.

(iv) Indian agritech startups find it tough to raise investments from international funds due to a lack of credible validation avenues available domestically. It is especially true for deeptech hardware, and digital and biological startups. Our agriculture universities need to become reliable sources of validation globally and they need robust marketing by India, very much like what the Netherlands does for Wageningen University and the United States for UC Davis.

(v) Similarly, many startups are manufacturing biologicals and derived products with a huge potential in the export market. Policy support is necessary for the accreditation of such factories, in line with the global standards, which can make it easier for Indian startups to go global.

We are sure these issues are solvable, but the process has to be sped up as it is becoming clear that agriculture is the key to our food security and, to an extent, our energy security as well. Agriculture is our soft power and has the potential to make India the breadbasket of the world. Therefore, it is imperative that the entire ecosystem comes together and makes this a reality.

Omnivore is an impact venture fund that invests in Indian startups developing breakthrough technologies for food, agriculture, and the rural economy. Having launched its first venture fund in 2011, Omnivore pioneered agrifood tech investing in India. Omnivore portfolio companies are working to transform food systems across India, making agriculture more profitable, stable, and sustainable.

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Endnotes

1 "World Population by Year", *Worldometer*, https://www.worldometers.info/world-population/world-population-by-year/

2 The Editors of Encyclopaedia, "Agricultural revolution", *Encyclopedia Britannica*, October 17. 2023, https://www.britannica.com/topic/agricultural-revolutionhttps://www.britannica.com/topic/agricultural-revolution

3 Autumn Spanne, "Green Revolution: History, Technologies, and Impact", *Treehugger*, August 17, 2021, https://www.treehugger.com/green-revolution-history-technologies-and-impact-5189596

4 "Land use in agriculture by the numbers", *Food and Agriculture Organisation*, https://www.fao.org/sustainability/news/detail/en/c/1274219/

5 "Half of the world's habitable land is used for agriculture"*, Our World In Data,* https://ourworldindata.org/global-land-for-agriculture#:~:text=If%20we%20combine%20pastures%20used,and%2037%25%20of%20total%20protein

6 "Only 8% of global crop land used for biofuels", *Oils and Fats International*, January 31, 2023, https://www.ofimagazine.com/news/only-8-of-global-crop-land-used-for-biofuels

7 Hannah Ritchie, Lucas Rodés-Guirao, Edouard Mathieu, Marcel Gerber, Esteban Ortiz-Ospina, Joe Hasell and Max Roser, "Population Growth", *Our World In Data*, https://ourworldindata.org/population-growth'

8 United Nations Population Fund, https://esaro.unfpa.org/en/news/worlds-population-hits-8-billion-people-un-calls-solidarity-advancing-sustainable-development-3

9 World Metrological Organisation, "COP22 advances global action on climate change", https://public.wmo.int/en/resources/meteoworld/cop22-advances-global-action-climate-change

10 Zia Haq, "India aims for better practices to cut agri emissions, experts call for clear goals", *The Hindustan Times*, November 10, 2021, https://www.hindustantimes.com/india-news/india-aims-for-better-practices-to-cut-agri-emissions-experts-call-for-clear-goals-101637068230083.html

11 Hannah Ritchi, "Sector by sector: where do global greenhouse gas emissions come from?", *Our World In Data*, https://ourworldindata.org/ghg-emissions-by-sector

12 "Land use per 100 grams of protein", *Our World In Data*, https://ourworldindata.org/grapher/land-use-protein-poore

13 Hannah Ritchie,"If the world adopted a plant-based diet we would reduce global agricultural land use from 4 to 1 billion hectares", *Our World In Data*, https://ourworldindata.org/land-use-diets

14 Hannah Ritchi, "Sector by sector: where do global greenhouse gas emissions come from?"

15 "Int'l day of awareness of food loss & waste reduction: Here's how food waste affects environment", *WION,* https://www.wionews.com/science/international-day-of-awareness-on-food-loss-and-waste-reduction-heres-how-food-waste-affects-the-environment-640920

[16] Dirk-Jan van de Ven, Iñigo Capellan-Peréz, Iñaki Arto, Ignacio Cazcarro, Carlos de Castro, Pralit Patel and Mikel Gonzalez-Eguino et al, "The potential land requirements and related land use change emissions of solar energy", *Scientific Reports*, https://www.nature.com/articles/s41598-021-82042-5#citeas

[17] Cropland Area by Country, *Worldometer*, https://www.worldometers.info/food-agriculture/cropland-by-country/

[18] National Food Security Mission, 2021, https://nfsm.gov.in/ReadyReckoner/CU1/CroppingIntensity_Jan2021.pdf

[19] Ministry of Food Processing Industries, Government of India, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1885038

[20] "Agriculture", *India Water Portal,* https://www.indiawaterportal.org/topics/agriculture

[21] Akash Podishetty and Sanjeeb Mukerjee, "Why is India a laggard in global fruit and vegetable market?", *Business Standard*, September 13, 2022, https://www.business-standard.com/podcast/economy-policy/why-is-india-a-laggard-in-global-fruit-and-vegetable-market-122091300073_1.html

[22] Omnivore, Indian Agriculture and the Era of AI, *Medium,* https://omnivore-vc.medium.com/indian-agriculture-and-the-era-of-ai-69826a094f5c

[23] "Simplifying agri-processing", agrizy, https://agrizy.in/

[24] The Confederation of Indian Industry, "*Indian Food Processing Sector*", August 2019, https://face-cii.in/wp-content/uploads/2021/09/Food-Processing-Report-2019.pdf

[25] Rukmathan R, "Food Processing Industry: Service Concepts, Issues and Its Scenario in India", *Journal of Business and Management*, https://www.iosrjournals.org/iosr-jbm/papers/Conf-ICSMTSA/Volume%202/9.%2030-33.pdf

[26] Ministry of Food Processing Industries, Government of India, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1885038

[27] Omnivore, "Omnivore Farm Logs | Why we invested in BioPrime", *Medium*, https://omnivore-vc.medium.com/omnivore-farm-logs-why-we-invested-in-bioprime-52c879143837

[28] Omnivore, "Loopworm: OmniX Bio's second investment in agrifood life sciences", *Medium,* https://omnivore-vc.medium.com/loopworm-omnix-bios-second-investment-in-agrifood-life-sciences-1c27f3b2beb8

[29] Arnold van Huis, "Potential of Insects as Food and Feed in Assuring Food Security", *Annual Review of Entomology*, 2013, https://www.annualreviews.org/doi/10.1146/annurev-ento-120811-153704

[30] Omnivore, "Omnivore Farm Logs | Why We Invested in altM?", LinkedIn, https://www.linkedin.com/pulse/omnivore-farm-logs-why-we-invested-altm-omnivore-partners/

[31] Bhupendra Koul, et al., "Agricultural waste management strategies for environmental sustainability", *Environmental Research*, 2022, https://www.sciencedirect.com/science/article/abs/pii/S0013935121015863

Unpacking Energy Transition for India: Expanding the Innovation Lens

Smita Rakesh

I. Skewed funding towards lower risk climate tech

While conversations on climate and energy transition are gaining traction more recently, the concept of 'just energy transition' reveals a complexity beyond initial appearances. It intertwines the layers of socio-economic inequities, which exist irrespective of climate change but get further accentuated due to it, with the marginalisation resulting from the existing skewed development model—an underlying driver of climate change itself. This complexity intensifies in regions undergoing energy system transformations and striving for renewable energy adoption.

The challenge is to harmonise development priorities with overarching emission reduction goals. It's crucial to distinguish two aspects: Firstly, at the energy system level—approached on a national and global scale—progress is evident, albeit slightly delayed. However, this trajectory often becomes obscure at sub-national and regional tiers, particularly in areas like India's coal-rich states. Whether this transition brings prosperity in the short and the long run, both, is now an intensely debated topic. How do we work on solving for layers of historical inequities while preparing

local economies for the future of energy? How can we ensure this transition is 'just' for a country that must provide universal energy access while transitioning towards a greener grid for over 1.4 billion people? And while a large part of the answer lies in innovation, technology alone isn't going to address it as the be-all and end-all. These innovations are vital not only for mitigating the environmental impacts of climate change but also for developing adaptive solutions that can protect and uplift the disadvantaged communities most adversely affected by its consequences.

Having said that, for science and technology-based innovation to play its part, an entire orchestra is needed to play along, most of the components of which are either missing or heavily disjointed and out of sync in India as of now.

Ironically, one of the most significant barriers confronting start-ups with innovative solutions and business models is the need for comparisons and benchmarks. This paradoxically hampers the innovative mindset, often constraining the commercialisation of potentially successful solutions. In the larger gamut of innovative solutions, too, there is a heavy skew in favour of services or platform-based solutions rather than products. This preference stems from the lower risk appetite and patience of capital providers, which discourages entrepreneurial risk-taking in this space. This also ends up making some sectors, such as electric vehicles (EVs), with a quicker and more assured returns prospect, a hot favourite for investors.

While the climate sector seems to attract investor attention, a closer examination reveals a more nuanced reality. Use cases and markets such as MSMEs (Micro, Small and Medium enterprises)—more than 99 percent of which comprises of micro-enterprises[1]—accounting for about 48 percent of the total energy consumed by India's industrial sector[2], are screaming from the lack of attention when it comes to innovation and funding. Deep-tech, high-risk, long-gestation areas such as energy storage and alternative materials are at the risk of running out of funding once the government grants dry up. The same is the fate for solutions working towards serving the underserved; for example, 85

percent of India's smallholder farmers[3]. These solutions, often classified as "incremental innovation" or "social innovation" with unforeseeable markets at scale, are typically cast aside for funding, be it philanthropic grants or institutional credit.

II. Social Alpha's expanded investment playbook for social equity

When we started Social Alpha seven years ago, one of the objectives was to break this dichotomy of for-profit and not-for-profit, and make capital of all kinds available to startups working on solving some of the most historically unsolved challenges. The allocation of funding needs to be based not solely on capital availability, but on actual necessity, relevance, feasibility and impact potential. Set up as a non-profit, Social Alpha makes both dilutive and non-dilutive capital available to early-stage startups based on recommendations after a needs assessment, impact potential, and a thorough business plan review.

It is essential to note that early-stage climate startups operating within an evolving market landscape often possess limited visibility into their cash projections. Therefore, adopting an objective yet adaptable approach to multi-year planning is crucial. To bridge the gap between investors and startups, there's a compelling need to move beyond the mainstream investment playbook and create space for the unknown rather than relying heavily on extrapolation that may lead to disconnection. Another shift we've embraced as investors, and recommend to the broader community, is to expand the scope beyond mere business goals and outcomes when finalising milestones and terms of definitive documents. Inclusive growth agendas encompassing impact, workforce inclusion, and the company's ethos hold more promise than what mere numbers might reveal.

At the heart of Social Alpha's climate strategy is a goal targeted towards net-zero, of supporting over 100 start-ups by 2025 with a combined emission avoidance potential of more than 1 Gigaton. Simultaneously, the strategy ensures that a minimum of 35 percent of these innovations directly contribute to enhancing the climate resilience and adaptive

capacities of the most vulnerable communities. This expanded climate agenda pursues two crucial paths. First, it advocates for the prioritisation of high-emission sectors and underserved user groups. Second, it underscores the importance of ensuring access (to energy, water, health, education and quality of life to all), security (of food, livelihoods, jobs), and de-risking those most likely to bear the brunt of the energy transition. Each of these solution segments requires a continuum of support all the way from their development in the lab to their introduction in the market and eventual integration within communities. Social Alpha's climate architecture, comprising of multiple R&D labs, thematic incubators, venture accelerators, blended capital pools, and deployment engines, is an attempt in this direction. This multifaceted approach endeavours to mitigate innovation risks, stimulate demand, and foster market entry.

III. Conclusion—Pushing for innovations of tomorrow (actually needed yesterday)

Science and technology innovations are indispensable in tackling the challenges posed by climate change. This imperative extends beyond achieving net-zero emissions; it also encompasses safeguarding the interests of the most vulnerable segments of society who bear the brunt of climate change despite having played no significant role in causing it. So, while the rest of the ecosystem will have to come closer and move in sync, funnelling support for start-ups from one stage to another, the innovations for tomorrow—which are ironically the innovations we needed yesterday—will also need to reimagine the needs of the growing population. This entails forging a more equitable and sustainable future in the face of this pressing global issue.

Social Alpha architecture is built around a not-for-profit platform, Foundation for Innovation and Social Entrepreneurship (FISE) and operates through a nationwide network of technology and business incubation infrastructure, sponsored and enabled by Tata Trusts, Government of India and a number of academic, philanthropic and corporate partnerships.

SOCIAL alpha

Endnotes

1 Ministry of Micro, Small and Medium, Government of India, *Annual Report 2022-23,* 2023, https://msme.gov.in/sites/default/files/MSMEANNUALREPORT2022-23ENGLISH.pdf

2 Ministry of New and Renewable Energy, Government of India, *"Identifying barriers for rooftop solar uptake in MSMEs and development of a mitigating financial framework",* 2020, https://solarrooftop.gov.in/knowledge/file-62.pdf

3 Ministry of Agriculture and Farmers Welfare, Government of India. *"All India Report on Agriculture Census 2015-16"*, 2020, https://agcensus.nic.in/document/agcen1516/ac_1516_report_final-220221.pdf,

The Venture Potential of the Electric Vehicle Sector in India

Arpit Agarwal and Venkatesh Modi

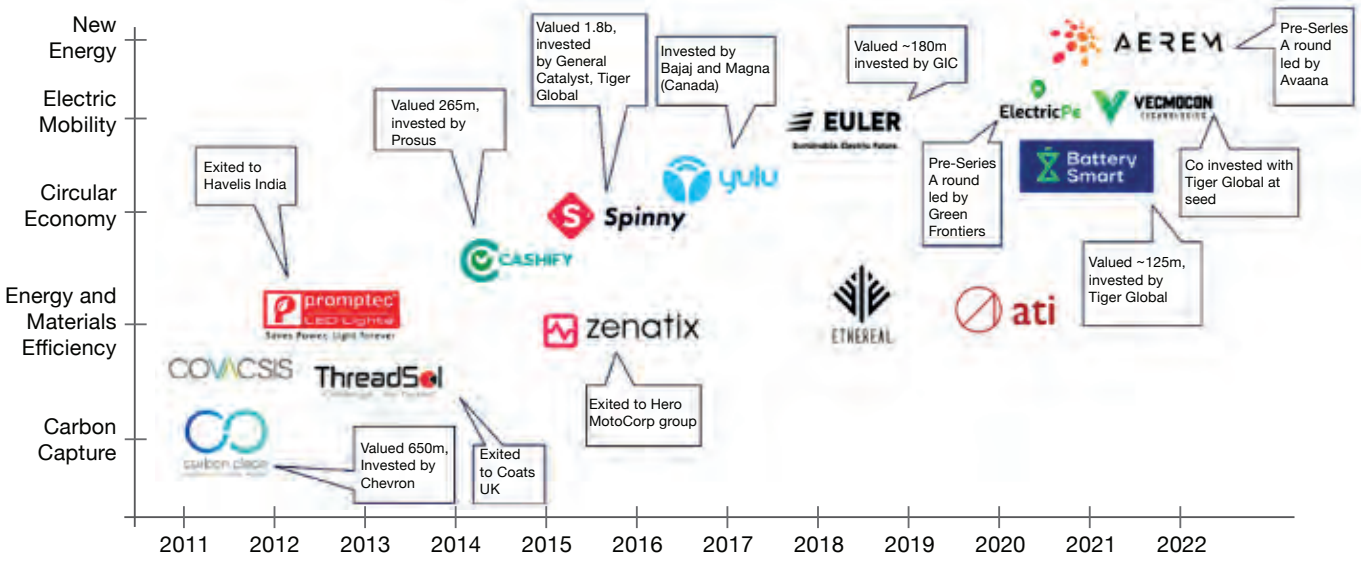
I. The rising flow of venture capital into global climate tech

The pace of venture investing into global climate tech startups is growing rapidly. As of January 2023, there were 83 climate tech unicorns recorded around the world,[1] of which were collectively valued at US$ 180 billion. In 2022, the US market invested US$ 87 billion into climate tech companies, compared with China at US$ 48 billion and India at US$ 6 billion.[2] Interestingly, with 3,300 deals being closed in 2022, the dominant sectors, which have seen the highest amount of capital raised, are energy storage, renewables, energy distribution, and electric mobility.[3] Furthermore, the year 2022 marked a massive surge in India-based venture capital (VC) funding, aided by the fact that Indian regulators, policymakers, corporates, and investors alike see the potential for India to take a leadership role in climate tech venture investing for homegrown and global startups.

II. Blume Ventures' climate tech thesis

Our journey in building our climate tech investment portfolio is captured below:

Blume Climate portfolio over the years



We began our investments into carbon capture and renewables at the onset of our first fund in 2011-13. Over the last decade, we also invested in energy efficiency technologies and circular platforms. When we launched our third fund in 2018, we started looking deeply at the electric vehicles (EV) sector. What excited us the most was that this sector could disrupt the entire automotive industry, while also leading to a climate-positive, net zero transition. It was this driving force that led us to invest in several EV companies that are scaling up cutting-edge technologies. Over the last 5+ years, we have invested in 5 EV companies: Yulu, Euler Motors, BatterySmart, Electric, and Vecmocon.

Since early 2021, we have been receiving pitches from multiple two-wheeler (2W) original equipment manufacturers (OEM) companies. After evaluating 50+ pitches, we aimed to ascertain the reason for the proliferation of these companies in the market. These companies had a few commonalities:

1. They claimed to have developed a superior Battery Management System (BMS);
2. They were all trying to raise US$ 10-20 million;
3. They were all pre-production, and therefore pre-commercialisation.

We were sceptical about backing a 2W-OEM company, not because they would compete with incumbent players, but because the barriers to entry to be a 2W-OEM company were very low. Additionally, when we looked deeper at the supply side of such 2W-OEM companies, we realised that there were very few suppliers of quality EV components in the market. The government's mandate and regulations for the use of indigenised components meant that if these companies were to benefit from the FAME II subsidies, they would have to source high-quality components locally, rather than relying on imports. This was a two-pronged problem, the first being access to robust components in abundance, and, the second, access to components locally.

On the demand side, the situation looked bleak as well: There were a large number of 2W EV brands emerging in the market, which meant this type of vehicle was set to become commoditised. In other words, there were too many choices for the end customers to buy from and hence as a 2W-OEM, they were broadly unable to command high sale prices and therefore robust margins. Hence, on both the supply and the demand side, with the margins of a 2W-OEM brand being squeezed, the result was an unsustainable business model. We decided this was a business that would not fit our VC mandate and hence we declined to invest into the entire sector of 2W-OEMs.

By virtue of serendipity, we came across Vecmocon (abbreviation for VECtor, MOtion, CONtroller) which had interestingly positioned itself upstream of the 2W-OEM value chain. This company was designing and manufacturing quality components and supplying them to OEMs. The team led by Peeyush Asati, Adarshkumar Balaraman and Shivam Wankhede have been working on this model since 2015, much before EVs were mainstream. They had been supplying the components to multiple OEMs, had large order books, and were profitable as well. They could potentially supply to the 200+ EV 2W brands that were emerging in India and build a large sustainable business. We were able to rapidly build our conviction in the VC investible case for this business. Subsequently, we led a US$ 5.2 million round into Vecmocon along with Tiger Global.

In the long term, we envision Vecmocon to build cutting-edge next-generation components for EVs across multiple segments—2W, 3W, 4W and buses. The ancillary components industry is very large (in India and globally) and with the rapid rise of EVs, we are hopeful that Vecmocon can disrupt this industry with their solutions and become a global leader. Therefore, our investment into Vecmocon pushed us to map the entire value chain of the EV industry and make a bold decision to back various other technologies in the EV sector.

Our EV investments now include: Euler Motors, a manufacturer of light commercial electric vehicles used for intra-city, hyperlocal goods transportation, such as for e-commerce or any last mile goods delivery; Electric Pe, an EV charging platform, which partners with thousands of independent charge point operators; Yulu, a dockless bike and electric scooter service across Indian cities; and Battery Smart, a network of battery swapping stations providing drivers of electric three-wheeled rickshaws a 2-min battery swap.

III. Recommendations for key actors

India has benefited from increased policies and regulations promoting the adoption of EVs and clean energy solutions, and this phenomenon can be described as “policy-led growth” (PLG) in the sector. However, a major obstacle to the widespread adoption of EVs and other clean energy solutions in India continues to remain the lack of adequate financing. These solutions are relatively new, hardware heavy and capital-intensive, making it challenging to assess and underwrite their future asset value. Enabling various forms of financing, such as government bonds, priority sector lending from private banks, and blended finance instruments, can significantly catalyse adoption.

Furthermore, addressing awareness is a critical issue that the government should actively tackle. Similar to the “Mutual Funds Sahi Hai” campaign, which the Indian government conducted in recent years to educate citizens about the benefits (and risks) of investing in a new and growing asset class, similar campaigns for EVs and clean energy could be developed. Increased adoption leads to greater traction, ultimately driving

scalability. Currently, India is at the initial stages of this journey, facing multiple challenges that require a concerted effort.

Additionally, India must make substantial investments in research and development (R&D). These investments can take various forms, including government grants, innovation challenges, publicly-funded research laboratories, innovation parks, and facilities equipped with world-class equipment and systems. Such investments have the potential to accelerate innovation in the country significantly and promote collaboration among various stakeholders. Moreover, involving the public in solving the challenges of achieving net-zero emissions is crucial.

Establishing the right innovation infrastructure, accelerating existing solutions through policies and financing, and enhancing public awareness are essential steps for India to reach its net-zero emissions targets.

IV. Conclusion

As we continue to build our footprint in the EV and the broader climate tech space, we are extremely grateful to the entrepreneurs who continue to build, flourish, and develop differentiated technologies to help propel India towards net zero carbon emissions and a climate-positive energy transition. While the current EV market in India is at a nascent stage, we believe that slowly, steadily but surely, India will be a global leader in EV adoption and the key actors at the forefront of this revolution will be venture-funded startups.

Blume Ventures is a home-grown, Indian venture capital, generalist fund, with exposure to most sectors and business models. The first fund, raised in 2011 was INR 100 Cr (~US$ 16M), followed by Fund II, which was US$ 60M and Fund III, which was US$ 100M. Blume is currently investing out of Fund IV, which has a corpus of US$ 290M and a strong focus on climate tech. Blume maintains Assets Under Management (AUM) of US$ 600M+ across its primary and opportunity vehicles.

Endnotes

1 "Global Climate Tech Unicorns: The complete list of Global Climate Tech Unicorns," Holon IQ, https://www.holoniq.com/climatetech-unicorns

2 "Defying gravity, 2022 Climate Tech VC funding totals $70.1B, up 89% on 2021," HolonIQ, https://www.holoniq.com/notes/2022-climate-tech-vc-funding-totals-70-1b-up-89-from-37-0b-in-2021.

3 Holon IQ, "Defying gravity, 2022 Climate Tech VC funding totals $70.1B, up 89% on 2021"

Building a Deep-Tech Ecosystem for Climate-Positive Venture Capital

Vishnu Rajeev

'India should be among the first nations to industrialise without carbonising the world'

— **Amitabh Kant,** India's G-20 Sherpa, former CEO of NITI Aayog and former IAS officer.

I. The need to invest in deep science technologies

As the fastest-growing economy in the world, India needs to balance pulling millions of people out of poverty while ensuring decarbonised growth. The need for new technology innovations and securing India's pathway to sustainable development underscores the need for investing in home-grown deep science and engineering-based technologies. Interestingly, more than 70 percent of the technologies required for the net-zero transition by 2070 are currently at the lab-scale prototype, pilot, pre-commercialisation, or early adoption stages, according to the International Energy Agency (IEA).[1] Moreover, the contribution of technologies at the prototype or demonstration stages is even higher in heavy industry and long-distance transport. The IEA estimation points to the large investment required in technology development and deployment required to facilitate the global energy transition. However, this also presents an opportunity for private capital, especially venture capital, to play a defining role in funding these innovative technologies.

II. Our climate thesis: India-centric sustainable development

At Speciale, we invest in futuristic technologies built in India that could revolutionise the course of human development. We look at innovations that are rooted in fundamental science and engineering, and the climate-positive transition is at the heart of Speciale's investment thesis. Solving environmental challenges through science and technology provides the dual opportunity to create societal impact and financial value for our stakeholders—portfolio companies and limited partners alike. Importantly, climate tech is a thematic area that cuts across several sectors. For

startups, building technologies applicable for these sectors will have a high potential to mitigate and adapt to the effects of climate change.

The core climate sectors that we have selected are the following:

a. Energy (responsible for 1561 MtCO2e (41.3%))
b. Industry (1119 MtCO2e (29.6%))
c. Agriculture (734.8 MtCO2e (19.5%))
d. Mobility (392 MtCO2e (5.2%))
e. Infrastructure and Buildings (197.6 MtCO2e (4.4%))

These sectors collectively contribute to over 70 percent of India's greenhouse gas (GHG) emissions and constitute nearly 65 percent of India's GDP.[2] Decarbonisation is the primary driver bringing disruption through technological and business innovations to these sectors. The sheer size of the market opportunity makes this space attractive to investors, financial or otherwise.

We search for and evaluate deep tech opportunities in the areas mentioned above, but we also assess companies building in cross-cutting sectors, for example, carbon capture and utilisation, nature-based solutions, carbon markets, climate data, and others. Securing India's energy future and economic development form the backbone of our climate thesis. We believe that our investments in deep science

and engineering startups will directly contribute to India's plans for decarbonised industrialisation while also creating large-scale employment.

In addition to the core climate sectors, we also invest in climate-adjacent ones, which we term as crucial in developing the core sectors. Examples include semiconductor innovations for a digitalised economy, or satellite-based data startups, which can provide valuable inputs for climate change mitigation.

III. Trends that shape climate-tech innovations in India

As one of the few deep tech funds investing in the climate-tech space in India, we have observed a few trends shaping the development of climate-tech innovations.

i. Deep tech innovators are building global climate solutions from India

A decade ago, the Indian venture ecosystem focused mainly on consumer and internet startups. However, over the last decade, Indian Software as a Service (SaaS) startups have made their mark on a global platform, and now, global SaaS startups are being built in India.

A similar playbook is being developed for Indian deep tech startups as well. We have observed that Indian-origin scientists and engineers are returning from abroad to build startups in India in the form of reverse brain drain. India stands to gain from this large pool of science-driven and research-oriented talent. For example, Rochan and Prasanta of Newtrace, a green hydrogen portfolio company of Speciale's, returned to build their company in India. Both have advanced doctorate degrees from Europe and had lucrative options to pursue their skills and passions, but they chose to come back to India. They met at Entrepreneur First and pivoted at least twice before pursuing an opportunity they are both passionate about, based on deep scientific research.

ii. Academia supporting the commercialisation of their researchers' innovations

IIT Madras and IIT Bombay are examples of universities that have devised sabbatical programmes to enable professors to build technology startups. All major IITs have incubation centres with deep-tech-focused programmes, and the Indian Institute of Science (IISc) hosts a panel of deep-tech experts to advise on startup incubation and those founders looking to commercialise their product beyond the lab stage. At Speciale, we are in touch with many professors who simultaneously build their own deep tech startups along with generating academic research, or are actively involved with mentoring a start-up.

iii. Government support in commercialising deep science research

The Indian government has been instrumental in supporting researchers to commercialise scientific innovations. Many successful lab-to-market innovations in the West have been possible only due to non-dilutive grants and low-cost debt provided by the governments in those countries. While India still has a long way to go in securing and amplifying the quantum of funding available to deep tech startups, the government support over the last few years has been very encouraging—through grant funding agencies such as BIRAC and FLCTD, as well as incubators such as C-CAMP Bangalore and Venture Centre.

iv. Private capital in India is taking more risks to invest in climate

India has a nascent venture capital (VC) ecosystem and is yet to witness more than one complete exit cycle. However, the last few years have been promising, with the volume of exits recorded and many VC funds making significant gains for their limited partner investors. Such returns have further emboldened VCs to take more risks and look beyond their comfort zone, namely the thematic areas of software, consumer, and internet startups. This has resulted in a larger number of mainstream investors making early bets into deep tech, capex heavy and climate-positive companies, such as battery recycling, green hydrogen and cell manufacturing.

v. Corporates realising the potential of deep tech startups

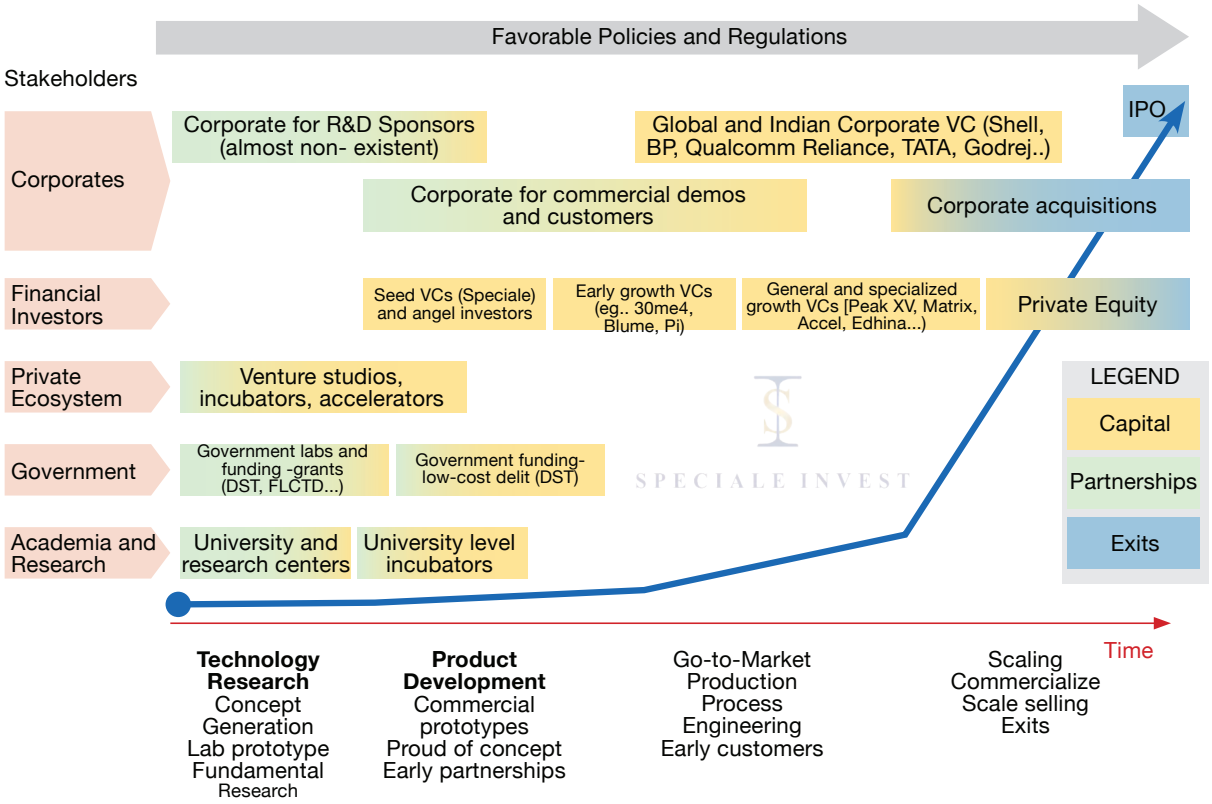
Large corporations can be key in sponsoring earlier R&D efforts of startups, partnering with these early-stage companies on commercial demos, being first customers, providing capital through their corporate venture capital arms, and being successful exit options for founders through acquisitions. For example, Indian public energy utility companies have partnered with our portfolio company, New Trace, to demonstrate their first electrolyser prototypes commercially. The corporate venture arms of global multinational companies such as Shell have invested in Indian startups like Off Grid Energy Labs (developers of the zing gel battery as an alternative chemistry to lithium-ion for mobility and stationary energy storage).[3] While we are yet to see a large exit for an Indian deep tech startup, we have examples of Indian corporates acquiring deep tech startups, such as Reliance acquiring UK-based sodium-ion battery company, Faradion.[4]

IV. An ecosystem for deep science innovations in climate

To foster deep-science innovations that can mitigate the effects of climate change, building an ecosystem of various stakeholders is essential. These innovations can never be built or commercialised in isolation but only with the active participation of various actors in the value chain. It is crucial to have the proper facilities to a) spark research and innovations; b) raise capital and hire resources to facilitate lab-to-market transitions; c) benefit from market conditions to scale up wide-scale adoption; and d) develop the right regulatory environment to facilitate all these steps.

Based on our learnings, below is the trajectory of deep tech startups that benefit from a vibrant and supportive ecosystem:

As demonstrated above, we have charted three stages for the scale-up of deep tech companies, with examples from our portfolio building in each of these stages:



i. Technology Research to Product Development

Our portfolio company, the ePlane Company, is India's answer to electric air mobility solutions (its Western counterparts include companies such as Joby and Lilium). ePlane Company is an electric vertical takeoff and landing (eVTOL) plane company that allows aerial movement of people and cargo. They are developing the most compact eVTOL in its category, allowing the plane to conduct short intra-city hops at a cost-effective rate. At emission levels of 50 gm of CO2e per person per km annually, an ePlane could save emissions equivalent to 30 taxis.

The ePlane company was founded by Dr. Satya Chakravarthy, a professor of aerospace engineering at IIT Madras (IIT-M). Incubated at IIT-M, ePlane was provided with infrastructure for the establishment of the initial technology as well as product development research facilities. Speciale Invest, along with other investors, invested the seed and early capital required for commercialisation. They are the only eVTOL plane approved by India's regulatory body for Civil Aviation, the Directorate General of Civil Aviation (DGCA).

ii. Technology Research to Go-to-Market

The New Trace team designed a green hydrogen electrolyser from scratch, which uses no rare earth metals and no membranes; has cost-effective power conditioning and water filtration equipment; and has 70 percent fewer components than traditional electrolysers. New Trace was a basic lab setup in one of the IITM labs.

They raised early capital from Speciale Invest and follow-on funding from Peak XV (earlier Sequoia India). The Department of Science and Technology, as part of the Government of India, also offered low-cost debt. Furthermore, New Trace initiated paid partnerships with Indian corporates and public-sector companies to demonstrate the commercial viability of their technology. New Trace is set for exponential scale-up by lowering capex and achieving a production cost for green hydrogen at US$ 1-1.5/kg in less than five years. With the proper set of Green Hydrogen policies and regulations, this growth would enable them to become a globally competitive green hydrogen company from India.

Moreover, our portfolio companies, such as e-TRNL Energy (novel Li-ion battery architecture) and Metastable Materials (novel battery recycling), are similar examples of startups at this stage.

iii. Technology Research to Scaling

Ultraviolette, an electric superbike company, began as an idea to develop a cutting-edge electric two-wheeler technology company from India. Their F77 model received over 70,000 pre-launch booking interest from over 100 countries and they have brought best practices from aerospace, aviation, and consumer electronics to create India's most advanced electric motorcycles. The company was started by Narayan Subramaniam and Niraj Rajmohan, a designer-engineer duo. It was a model ahead of its time before the EV revolution kickstarted in India. The company has raised US$ 55 million in funding since Speciale's investment from corporate and private equity (PE) investors, including TVS Motor Company, EXOR Capital (investor in Ferrari), Qualcomm Ventures, and Zoho Corporation.

V. Recommendations for stakeholders

Various stakeholders must unite and build the ecosystem to facilitate the transition towards an energy-secure and climate-resilient India. Promoting deep tech innovations can play a major role in facilitating this transition while catapulting India into a global industrial powerhouse.

(i) **Government:** The Indian government has taken an important first step in this direction with the National Deep Tech Startup policy. It encourages nurturing innovation at the research centres and finding the path to commercialisation of such innovations. It also lays out incentives for investors and corporates to support the ecosystem. As a next step, it would be beneficial for the government to work on climate-tech-focused policies and encourage the climate ecosystem to embrace multiple forms of capital that could truly unlock the sector's potential.

(ii) **Investors and Financiers:** To truly embrace the benefits of the deep tech ecosystem, private capital needs to warm up to the opportunity in the climate space. Indian venture ecosystem and capital at various subsequent stages—growth and private equity—are yet to realise the large under-explored opportunity in deep tech. Investor confidence depends on the creation of winners. India hasn't yet seen a deep tech winner gaining traction at a large scale, however, it is only a matter of time before this happens.

As technology readiness improves, deep tech startups need non-dilutive grants during their initial stages to address the science risk, a mix of equity and grants as the prototypes are built, and a mix of equity and debt when scaling up. For example, the early stages of research for lithium-ion batteries used in our mobile phones and electric vehicles were completely funded by governments through grants. However, today, most companies that are making lithium-ion technology innovations are funded through equity and debt capital. More proven technologies are less risky and opt for debt capital as it is cheaper than equity.

(iii) **Academia and Research:** Research facilities in India need further collaboration with industry. A greater push is required to create technologies in these research facilities that could cater to the demands of not just the Indian industry but also global ones. Partnerships with global corporates to promote innovation and commercialise these technologies are the most important step in this direction. Global steel giant ArcelorMittal's collaboration with IIT Madras to decarbonise the steel industry is a positive step forward in this direction.[5]

VI. Conclusion

The above examples showcase trends pointing towards a radical evolution in shaping the Indian story around climate transition and energy security. Indian deep tech is a fast-growing opportunity, and climate is likely to be the largest opportunity within this theme.

Technology disruption is happening at a swift pace, not just in software but also in hardware innovation, which is transforming the pace at which the commercialisation of science and technology is taking place. We at Speciale are committed to supporting India's low-carbon industrialisation by building a venture ecosystem to support the most cutting-edge deep science and engineering companies built in India, for the world.

Founded in 2017 by co-founders Vishesh Rajaram and Arjun Rao, Speciale Invest is a seed-stage venture capital firm that invests in founders building technologies of tomorrow. The firm backs ingenious entrepreneurs who use disruptive technologies to find innovative solutions that make an impact. The fund's investment areas range from deep science and technology sectors, especially Industrial Hardware Products (emerging from deep tech in Propulsion tech, Robotics, Rocket engines, Lithium tech, Micro-electronics, Green hydrogen, etc.) to Enterprise Software Products (emerging from deep tech in Cloud, Voice & Vision ML/AI, Image Analytics, AR/VR).

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Endnotes

1 *"Clean Energy Innovation",* Paris, IEA, 2020, https://www.iea.org/reports/clean-energy-innovation

2 Rajat Gupta, Shirish Sankhe, Naveen Unni, and Divy Malik, *"Decarbonising India Charting a pathway for sustainable growth",* Mckinsey Business, 2022, https://rb.gy/cbe1g

3 Laxitha Mundhra, "Offgrid Energy Labs Secures Funding From Shell, Ankur Capital & APVC," *Inc42,* February 15, 2022, https://rb.gy/1qvrs

4 Alex Scott, "Reliance buys sodium-ion battery start-up," *c&en*, January 17, 2022, https://pubs.acs.org/doi/full/10.1021/cen-10002-buscon4

5 "ArcelorMittal launches XCarb™ Innovation Fund Accelerator Programme for breakthrough climate tech start-ups in India," *ArcelorMittal,* July 11, 2023, https://corporate.arcelormittal.com/media/news-articles/arcelormittal-launches-xcarb-innovation-fund-accelerator-programme-for-breakthrough-climate-tech-start-ups-in-india

Enabling Technology-Driven Climate Solutions for Emerging Markets

Rema Subramanian and Suraj Nair

I. The scope for climate-positive technologies in India

India is the third-largest emitter of greenhouse gases (GHGs) in the world.[1] In 2021, India emitted 3.9 billion metric tons of carbon dioxide equivalent ($GtCO_2e$), accounting for roughly 7 percent of the total global emissions. The majority of these emissions (approximately 50 percent) originate from the combustion of coal, and the second-highest source of emissions comes from agriculture and land cultivation. While there is a large global focus on climate change, we believe that climate solutions for economies such as India are still nascent today and will grow exponentially over the next decade. As a fund, we at Ankur Capital have been investing in climate for a decade. We have seen impactful local solutions emerge in India and we continue to believe that these will multiply in volume in the next decade.

II. Building transformational tools at the early stage

Achieving the net zero target by 2070 will require transformational technologies to effectively catalyse the climate-positive transition. These tools are needed to enable climate mitigation, adaptation, measurement

and reporting. Here, we see four key investment opportunities—i) disruptive climate technologies, which can replace carbon-heavy industrial processes for mitigation ii) digital technologies to optimise supply chains for a lower carbon footprint; iii) tools for capturing carbon and related data for accounting purposes; and iv) digital technologies and solutions for climate adaptation.

i) Disruptive climate technologies to replace the fossil fuel-dependent industrial processes

The most direct and disruptive route to reduce carbon emissions is to replace incumbent industrial processes and technologies with innovative greener technologies. One of the most successful and scalable examples is electric vehicles (EVs) replacing Internal Combustion Engine (ICE) vehicles. Estimates forecast that EVs over their lifetime will emit less than 50 percent of the greenhouse gases (GHGs) released when compared to fossil fuel-powered vehicles.[2] The number can be reduced further depending on the use of renewable energy in the manufacturing process. Our portfolio company Offgrid Energy Labs is developing a zinc-gel battery (as an alternative to both lead acid and lithium ion chemistries) using sustainable and recyclable materials. The company contributes to both the areas of clean battery energy storage systems and low carbon mobility. Three-wheeler vehicles across developing economies in Asia and Africa, which have traditionally used two-stroke diesel engines and have been high-volume emitters, can successfully transition to zinc gel batteries at low upfront cost.

Disruptive climate-positive technologies are also changing the landscape of the agriculture and food production systems, which contribute to approximately 26 percent of global greenhouse gas emissions.[3] Agriculture inputs such as fertilisers, pesticides, and seeds are all witnessing rapid disruptive innovation in favour of greener alternatives. For example, our portfolio company String Bio is converting methane into proteins with applications in food, feed and agricultural inputs. The company has developed a unique synthetic biology-based microbial platform for this purpose. The company's proprietary biostimulant CleanRise® improves rice yield by 30-40 percent while reducing methane emissions from

paddies by 60 percent. Rice cultivation contributes to 12 percent of global methane emissions;[4] methane is a greenhouse gas that is 25 times more potent than carbon dioxide.

Moreover, meat production using animal husbandry accounts for almost 60 percent of the GHG emissions from food production,[5] but new innovations are replacing conventional forms of industrialised livestock agriculture. One example is in the cultivated meat industry, which is the production of meat tissues in large-scale lab fermenters, which can replicate the nutritional as well as organoleptic properties of real meat. MyoWorks, one of our portfolio companies, is developing mycelium-based scaffolds that can support the development of cultivated meat products by mimicking the multicellular architecture of real meat. Cultivated meat products can significantly reduce land and water usage by more than 90 percent while also reducing GHG emissions.[6]

Computational approaches coupled with CRISPR (DNA and genome sequencing technology) are enabling us to produce food differently by enabling the presence of desirable crop traits within the crop itself to produce higher yields. Tessol, another portfolio company, has developed a recyclable phase change material (PCM) as a sustainable alternative to the cold chain supply systems. The company has been able to reduce more than 1 million metric tons of GHG emissions.

What is most exciting about many such disruptive technologies is that they are built in India, and broadly target the global markets. Developing disruptive tools that tackle the carbon emissions problem in developing countries such as India is critical to addressing large-scale climate mitigation.

ii) Digital technologies to formalise supply chains and reduce losses

Interestingly, 80 percent of carbon emissions for large companies originate from raw materials and their supply chains, otherwise known as Scope 3 emissions, as per a McKinsey report.[7] This cuts across industries such as agriculture, textiles, electronics, and manufacturing. In fragmented markets like India, where production is distributed, we believe that

technology will be critical to manage footprints and drive carbon-related decisions, particularly with Scope 3 emissions taking centre stage. A powerful, digitally enabled, low-carbon supply chain can reduce wastage, monitor production processes, and optimise inefficiencies in logistics.

Digital technology platforms can also enable buyers with direct transparent access to sustainable, climate-positive products. One example is the agriculture industry, where digital solutions are being used to monitor production processes, optimise logistics, and limit wastage. Furthermore, food wastage is linked to 8-10 percent of annual GHG emissions.[8] Our portfolio companies, Captain Fresh and Vegrow, are leveraging digital technology to match demand and supply for perishable commodities, reducing food waste from around 30 percent to single digits. Additionally, companies like BigHaat are using their digital platforms to connect buyers with sustainably grown crops, enabling customers to make planet-friendly choices.

iii) Data collection and analysis to measure the carbon emissions and its impact

Our legacy accounting systems are ill-equipped to bear the costs associated with rising carbon emissions. This has to change as we transition towards a more sustainable future. The global carbon accounting market is worth US$ 12 billion and is expected to reach US $65 billion by 2030.[9] As regulators establish measurement scope and standards, it is crucial to provide organisations with the tools and solutions they need to comply with reporting requirements. Currently, consultants rely on traditional resource-intensive methods to manage and audit carbon credits. However, we believe that the future lies in the intersection of software- and hardware-led measurement methodologies that can scale and provide authentic and cost-efficient data. These measurement and integration tools will likely need to be tailored to specific sectors to meet their unique needs.

Cropin, one of our investees, is an example of a company operating at this intersection. They use remote sensing technology to provide visibility on agricultural production footprints, helping farmers and

organisations understand their environmental impact. As regulation on enforcing carbon disclosures becomes more pervasive, we anticipate that these measurement and integration tools will become more integrated with reporting systems. This integration will facilitate more accurate and efficient tracking of environmental data, allowing organisations to better understand and manage their carbon footprints.

iv) Technological and financial support to resist and adapt to climate change

While the above solutions are catered towards climate mitigation, both adaptation and resilience will play an important role in the near future to combat the climate crisis. IBISA Network, another portfolio company of ours, is working in the agriculture value chain to provide innovative parametric insurance solutions against the adverse effects of climate change such as droughts or excess rainfall. Up to 70 percent of the global food supply is grown by smallholder farmers,[10] who comprise more than 85 percent of the total workforce in agriculture and allied sectors in India.[11] With climate change accelerating at a rapid scale, most of these smallholder farmers are vulnerable to unforeseen climatic conditions that lead to crop damage. IBISA is developing insurance products using climate-related data sets to address the large gap between the cost of insurance and the ability to pay premiums versus the existing insurance offerings and the farmers' needs.

Apart from crops, IBISA is also developing products for livestock loss. The company has developed an innovative heat index-based insurance product to protect against the reduction in cattle milk yield in summer. It uses a satellite-based system to measure temperature parameters and provides a payout if the temperature breaches a pre-fixed threshold. Similarly, another portfolio company, Piatrika Biosystems, is developing an intelligence platform using genomic and phenotypic data from the fields to accelerate the development of climate-resistant seed varieties. The company can reduce the timeline of new seed development by more than 50 percent.

II. Recommendations for key stakeholders

India is a unique country, juggling between disruptive growth and the effects of rising carbon emissions. The growth can be sustainable and greener but for this to happen, we will need participation from all stakeholders in the ecosystem. For example, we need the government to incentivise the transition towards greener solutions by developing favourable policies, and supporting innovation in the form of R&D funding and grants, and enforcing stringent regulations on reducing GHG emissions. Furthermore, industries should be incentivised to tap into the climate-positive opportunity, actively adopt green solutions and work with startups to promote technology transfer and scale up. Finally, startups need to be encouraged to develop India-specific climate solutions, which can be replicated across other emerging markets.

III. Conclusion

We at Ankur Capital have been investing in climate tech since our inception. A market like India is distinctive—we have to balance both planet and people, which makes it even more imperative that there are effective technology tools to enable this energy transition. We cannot ask a small-holder farmer to reduce his production and income to meet climate goals. Rather, we need to find a way to balance the income and the planet. While compensation mechanisms through carbon credits is one way, we also believe that the farmer needs the tools to reduce his carbon footprint and increase his income. We believe that future opportunities in climate need to be holistic, people-positive, accurate, and transparent to create long-term value. What is good for the planet, makes for a good opportunity for us to invest in.

Ankur Capital is an early-stage venture capital firm investing in digital and deep science technology companies. Founded in 2014, Ankur Capital uncovers and unlocks opportunities in overlooked markets across India.

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Endnotes

1 "The Carbon Brief Profile: India", *CarbonBrief*, March 14, 2019, https://www.carbonbrief.org/the-carbon-brief-profile-india/

2 "Electric Vehicle Myths," *United States Environmental Protection Agency,* August 28, 2023, https://www.epa.gov/greenvehicles/electric-vehicle-myths

3 Hannah Ritchie, "Food production is responsible for one-quarter of the world's greenhouse gas emissions," *Our World in Data,* November 6, 2019, https://ourworldindata.org/food-ghg-emissions

4 Julia Kurnik and Katherine Devine, "Innovation in Reducing Methane Emissions from the Food Sector: Side of rice, hold the methane," *World Wide Fund for Nature,* April 12, 2022, https://www.worldwildlife.org/blogs/sustainability-works/posts/innovation-in-reducing-methane-emissions-from-the-food-sector-side-of-rice-hold-the-methane

5 Oliver Milman, "Meat accounts for nearly 60% of all greenhouse gases from food production, study finds," *The Guardian,* September 13, 2021, https://www.theguardian.com/environment/2021/sep/13/meat-greenhouses-gases-food-production-study#:~:text=2%20years%20old-,Meat%20accounts%20for%20nearly%2060%25%20of%20all%20greenhouse,from%20food%20production%2C%20study%20finds&text=The%20global%20production%20of%20food,major%20new%20study%20has%20found

6 Elliot Swartz and Claire Bomkamp, "The science of cultivated meat," *Good Food Institute,* https://gfi.org/science/the-science-of-cultivated-meat/#:~:text=One%20study%20showed%20that%20cultivated,90%25%20compared%20to%20conventional%20beef

7 "Starting at the source: Sustainability in supply chains", McKinsey Sustainability, 2016, https://www.mckinsey.com/capabilities/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains

8 Hamish Forbes, Tom Quested and Clementine O'Connor, *Food Waste Index Report 2021,* Nairobi, United Nations Environment Programme, 2021, https://www.unep.org/resources/report/unep-food-waste-index-report-2021

9 "Carbon Accounting Software Market Size Expected to Reach USD 64.39 Billion, With 22.8% CAGR by 2030", *Globenewswire*, March 6, 2023, https://www.globenewswire.com/en/news-release/2023/03/06/2620839/0/en/Carbon-Accounting-Software-Market-Size-Expected-to-Reach-USD-64-39-Billion-With-22-8-CAGR-by-2030.html

10 Hannah Ritchie, "Smallholders produce one-third of the world's food, less than half of what many headlines claim," *Our World in Data,* August 6, 2021, https://ourworldindata.org/smallholder-food-production#:~:text=How%20much%20of%20the%20world's%20food%20do%20they%20produce%3F&text=It%20is%20often%20claimed%20that,for%20agricultural%20and%20development%20policies

11 Ministry of Agriculture & Farmers Welfare, Government of India, https://pib.gov.in PressReleasePage.aspx?PRID=1920204

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